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WinCamD

Beam Imager

User Manual

VERY IMPORTANT

This VITAL information is here so that you cannot miss it.

- You ***may*** hot-plug and unplug a WinCamD series camera head from its cable. You ***should*** do this when moving the camera. Dragging the cable with the camera will loosen the cable retention socket.
- **Do not** accidentally plug a different Firewire cable into the WinCamD PCI card or the camera head. You may damage the camera head or the card or the other unit.
- You may install a BeamMap, Beam'R, BeamScope or ColliMate PCI card & a WinCamD PCI card in the same PC. However, currently, only one system will operate at any one time.
- To avoid camera damage, **observe the maximum irradiance limits**, Section 1.7.2. Damaged CCD chips can be replaced, but at customer expense.
- See Section 3.6.3 for instructions on cleaning the ND filter and, in extremis, the chip.
- **Centering**. Beams should be centered on the instrument for accurate measurements. If energy spills outside the imaging area, erroneous measurements may result.
- **Learn to save files and for future reference**: Via the Pull-down menu go:

  File, **Save**, **Save current data** … to save the single profile/image set, or:

  Save all data in data buffer … to save a sequence of data, particularly if you are seeing instability. The saved file (***.wcf**, format) includes setup data for your instrument. Anyone with the software can then view the data exactly as you see it.
- If the software appears to be giving strange results or the screen layout is corrupted, in the Pull-down menu, try **File**, **Load defaults** to reset the default settings, and/or restart the software.

  If you continue to get a result or inconsistency that you do not understand, *before you report it*, save a file. Email the result to your distributor or to **support@dataray.com** with your commentary. Then call.
- **Read the Manual**. If User Manual authors had their way, this paragraph would read: "If you read this manual first, you are entitled to free product support by phone, fax or email. For those who decide not to bother to read the manual before calling for support, a Help line charged at a 'per minute' rate is available." …

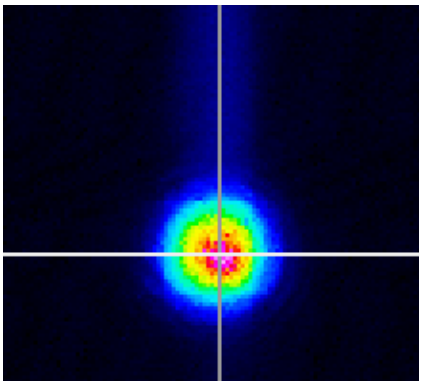
  … seriously though, read this manual to enjoy the full benefit of your investment.

Software/Hardware Release Issues

The current software, Version 3.06H6 at the time of writing, is fully functional. Version 4.XX with faster capture and other additional features will be available Fall 2002 from the website. The following other items might arise:

- **WinCamD/IR** supplements will be posted to the **Sales and Support**, **Application Notes** section of the DataRay website.
- **Vertical Tail**. At exposures below a few hundred microseconds an attached vertical tail may appear for CW image sizes of 1024 x 1024 and higher and a detached tail for 752 x 752. At 512 x 512 and below, the tail virtually disappears.

  This is a function of the high resolution CCD chip and this effect is unavoidable. Light incident on the chip can leak through to the Interline Transfer Register. The effect is worse at longer wavelengths and for beams incident at other than normal incidence.

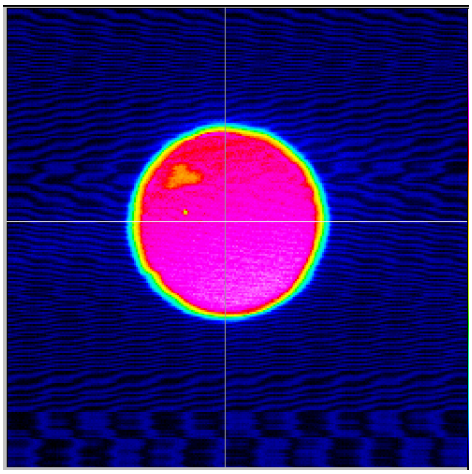
  To minimize the effect of the tail, use some combination of the following:

  1) Use exposure times above 10 ms wherever possible.
  2) Ensure that the light is normally incident, wherever possible.
  3) Set up a Capture Block appropriate to the size of your beam.
  4) Use Inclusion region settings to exclude the tail region from the calculation.
  5) Set the crosshairs at an angle other than 0^{o} to move the measured profile off the tail.

Firmware Upgrades. If your camera and or PCI card require a Firmware upgrade, the message shown right will appear. Contact the factory or your local distributor.

CCD Gain. The [reworked] first small production batch of WinCamD cameras and single-input PCI cards requires the user to set the minimum CCD gain at x5 to achieve full range on the ADC. The useful gain range is therefore x5 to x5.7. The second and subsequent production batches extended this useful range to x1.3 to x5.7.

Background noise. Some early shipments had a susceptibility to PC power supply noise which was not apparent on our final test PCs at the time of shipping. If you see a substantial 'wood-grain' pattern in the background, save it as a *.wcf file and contact us for repair/replacement.



Software bugs? We attempt to ensure that the software is as bug-free as possible, but - just like certain major operating system providers - we find it hard to be perfect. It is literally impossible to test every one of the many possible permutations and combinations of beam size, capture block, image processing combinations, etc.

If you see a problem, please note the problem, wherever possible capture a relevant ***.wcf** image file, and email the file and the details of the PC and operating system to: support@dataray.com. We will attempt to resolve the issue as soon as possible.

WinCamD

CCD Beam Imager

User Manual

Serial Number: _____

Purchased by: _____

Date: _____

Rev. 0210A
Updates will be posted to the website.

October 2002

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info@dataray.com • www.dataray.com

Product Support: (303) 543-8235 • support@dataray.com

Table of Contents

CHAPTER ONE

1 INTRODUCTION

1.1 WELCOME

Welcome to beam imaging. These innovative products define state-of-the-art, feature-rich, real-time, CCD camera based beam imaging in accordance with the ISO 11146 Standard*. They are designed as research, development, QA and manufacturing test tools that can be easily customized to your application. The program combines easy-to-use intuitive software and proven beam profiling algorithms. With a little time and patience, we think you will be pleasantly surprised with how easy to use we have made it.

[* International Organization for Standardization. 'ISO 111146: Test methods for laser beam parameters: Beam widths, divergence angle and beam propagation factor.' Available from www.ansi.com]

This manual covers both the WinCamD™, WinCamD/IR and the TaperCamD™. These products replace the WinCam-PCI product line. We welcome requests for custom hardware configurations.

We are committed to providing the ultimate in beam imaging performance, and welcomes constructive criticism of these products and of this manual. Please contact us.

The website is always the source for the most current versions of software, manuals, application notes, specifications, parts lists, etc. At any time, you may download the latest version of the software and/or manual updates and application notes for free. Visit the website in order to determine whether an update is available.

If you need a function that is not included in the current version, please fill out and fax a Function Request form found as Appendix A of this manual. Many requested software functions can be added with relative ease, and may be done for free, and possibly added

to future releases. However, if the requested embellishment is considered extensive and/or obscure, we reserve the right to quote a fee for the requested change.

Software bugs. We attempt to ensure that its software is as bug-free as possible, but just like certain operating systems companies, we find it hard to be perfect. It is literally impossible to test every one of the many possible permutations and combinations of beam size, capture region, capture combinations, etc. If you see a problem, please note the problem, capture a relevant ***.wcf** image file if possible, and email to technical support. We will attempt to resolve the issue as soon as possible.

1.2 ABOUT WINCAMD

WinCamD represents state-of –the art approach to real-time beam imaging. It uses a high resolution progressive scan CCD chip with 1360(H) x 1024(V) 4.65 mm square active pixels. This chip is directly addressed via customized gate arrays.

The chip is driven by an 8 MPixel/s readout clock (16 MHz master clock). A faster clock would increase the noise and a slower clock would reduce the frame rate. The **FULL** mode captures every line. The **FAST** mode bins adjacent lines and adjacent pixels, creating a single effective pixel from four adjacent pixels. The number of lines in the **Capture Block** can be changed from 1 to 1024. The approximate frame rate may be calculated as:

FULL frame rate ≈ 4 x (1024/Number of lines in **Capture Block**)

FAST frame rate ≈ 8 x (1024/Number of lines in **Capture Block**)

For low **Capture Block** line counts, PC processing limits the maximum frame rate.

The Advantages of 14-bit Analog to Digital Conversion and 'Digital' cameras

ADCs. When CCD beam profilers first came out in the early 90's, CCD's were relatively noisy. 8-bit (256 level) ADCs could adequately sample the signal and the noise *if the peak signal was close to saturation*. [Using WinCam-PCI's continuously variable Eclipse™ electronic shutter, this condition could always be met on CW beams.]

As CCD noise & ADC prices decreased in the late 90's, some manufacturers offered 10-bit (1024 level) and 12-bit (4096 level) ADC options, though for a significant price increment. For the customer, this meant having to compromise between performance and price.

WinCamD deletes the 'How many ADC bits can I afford?' dilemma from the buying equation. Taking advantage of the latest lower noise Sony CCD chips (10 to 11-bit equivalent noise) and of ADC price reductions, we provide a 14-bit (16,384 level) ADC on all WinCamD systems. For the customer this gives ultimate performance *at no extra cost*. The full 14-bit ADC capability may be used with cooled analog CCD cameras.

"Digital" cameras. In WinCamD, the software talks directly to the CCD chip, avoiding the limitations of the manufacturer's chipset. This enables external trigger, wider shutter speed control and user-defined image capture regions with higher update rates. Placing the ADC in the head allows a digital link from head to PC card, insensitive to the EMI (Electro-Magnetic Interference) problems that can plague analog video links in high power pulsed laser measurements.

1.3 SYSTEM CONFIGURATION

WinCamD imaging systems consist of the (interchangeable) camera head, a PCI card a three meter long FireWire–style cable, and the latest version of the software. The system is shipped ready to install on any 500 MHz or higher Pentium III PC with 256 MB of RAM and an available PCI card slot. Longer connecting cables up to 4.5 m (15 ft.) are available.

A Notebook PC compatible version is available using a Magma CB1H PMCIA to PCI adaptor. [**www.magma.com/index2.html**].

1.4 FUNCTIONAL DESCRIPTION

The following is a brief description of the WinCamD working principles.

A Sony progressive scan 1/2" CCD chip with 1360 (H) x 1024(V) 4.65 ㎜ square pixels is driven directly via a programmable gate array with embedded 'firmware.' WinCamD software can:

- Define the **Capture Block**, the area of the CCD from which the data should be taken, and the **Inclusion Region** for which the data should be analyzed. In this mode, the capture rate in frames per second can increase.
- Work in ***Fast*** mode at half the **Norm**al resolution for initial setting up and alignment.
- Automatically set the correct exposure time, 16 ㎳ to 1024 ms, for CW lasers, using Eclipse™ automatic electronic shutter.
- Vary the gain by a factor of 4.4:1 for pulsed lasers.
- Accept an external trigger from, or generate an external trigger for, a pulsed laser.
- Automatically synchronize to the pulses from lasers with prr's (pulse repetition rates) between 100 Hz and 50 kHz.
- Advance or retard the capture timing with respect to an external trigger or the synchronized timing.

- Process the acquired image in a number of ways.
- Average and/or smooth the images.
- Log the data and display the logged data.

1.5 CALIBRATION

Dimensional beam calibration of a WinCamD/1M4 and /IR camera heads is an intrinsic calibration based upon the precision of Sony CCD photolithography. The nominal dimensions of the chips and pixels are used in all calculations. The accuracy is believed to be *much better than* – 1%, and probably close to 0.1%.

Dust on the ND filter or the chip can affects the measured image and affect the accuracy.

Dimensional beam calibration of TaperCamD's is limited by the –2% pincushion or barrel distortion of the fiber optic tapers.

1.6 WINCAMD PRODUCT SPECIFICATIONS

[Product specifications are subject to change without notice.]

ITEM	SPECIFICATION
Measurable Sources	CW beams Pulsed sources. 1Hz to ~50 kHz with single pulse isolation User configurable Synchronous, Asynchronous & Variable Delay trigger options. Software programmable trigger input, +ve or –ve edge, 50 W or 1 kW
Measured Beam Powers	*See the Maximum Power Graph and Notes, below.* E.g. ~2 mW to 100 mW, for a 1 mm diam. Gaussian beam @633 nm. (ND4 filter on)
Wavelength Range: WinCamD Third party cameras (CCIR, RS-170)	350 to 1150 nm. 355 nm operation requires attenuation other than the ND filter. [Works down to 190 nm but degrades over time.] Startech UV imaging plate cameras for <350 nm are available. UV, NIR and IR. X-ray to 20 mm. Contact us or visit website.
Electronic Dynamic Range CW beams	48 dB (60,000:1) for ~30 dB SNR, using variable

	electronic shutter)
Pulsed, Pulse-width <5 ㎳	6.5 dB (4.4:1) for ~30dB SNR, using CCD gain control only.
Pulse-width >5 ㎳	6.5 dB (4.4:1) for ~30 dB SNR, using CCD gain control only.
	6.5 dB + [Pulsewidth /5㎳]:1
Manual Beam Attenuation, all beams:	Provided ND 4.0 C-mount Neutral Density filters. See figures below.
	[ND 4.0 –1 at 546 nm, higher in blue and UV, lower in near IR.]
Options:	**EAM-2** 4-wheel stepped variable attenuator, 0 to 90 dB
	CUB and **CUB-UV** 3 to 10 % beam samplers for high power beams
	1% and 0.05% Holographic Beam Samplers (by **gentec electro-optics**)
	See additional data sheets at website and User Manual.
ADC converter	14-bit ADC in head. *All models*.
Imaged Beam Dimensions	*For the best results, beam diameter should not exceed half the array dimensions.*
WCAMD	Directly: ~50 ㎜ diameter to 6.32 x 4.76 mm 1360 x 1024 pixels, 4.65 ㎜ square
TCamD	Directly: 120 ㎜ diameter to 14.2 x 10.7 mm Pixels 10.5 ㎜ square. 2.25:1 fiber optic taper on WCamD
TCamD20/15	Directly: 160 ㎜ diameter to 19.6 x 14.8 mm Pixels 14.4 ㎜ square. 3.3:1 fiber optic taper on WCamD
	Smaller, or indefinitely larger beam diameters can be reimaged. Contact us.
Measurement Accuracy	0.1㎜ processing resolution
	Accuracy depends upon beam, characteristics.
Measured & Displayed Profile Parameters	Beam Diameter:
	At user defined Clip level
	Gaussian & Second Moment
	Equivalent diameter above a Clip level
	Equivalent Slit
	Angular Divergence
	Beam Fit: Gaussian profile fit & % fit
	Top Hat profile fit & % fit

	Equivalent Slit profile
	Ellipticity: Major, Minor & Mean diameters. Auto-orientation of axes.
	Centroid Position: Relative and absolute
	Intensity Weighted Centroid and Geometric Center
	Beam Wander Display and Statistics
	Filtered profile: 1x1 to 4x4 pixel, area averaging
Displayed Profiles	X & Y with superimposed Gaussian or Top Hat fit. Zoom x1 to x10
Displayed Plots	User set curves showing % acceptable deviation from Gaussian
Displayed Target	2-D & 3-D plots (10,16 or 256 colors or gray). Color contour plot at 10% intervals
	Zoom x1 to x32
	White perimeter circle at Centroid
	4 pixel black spot at beam Peak
	Double bulls-eye centered on crosshairs or CCD chip (on/off option)
Processing Options	Image averaging, 1, 5, 10, 20, continuous
	Background Capture and Subtraction
	User set Capture region
	*.job files save all WinCamD custom settings for particular test configurations
Image Update Rate	Few Hz maximum for full frame, full screen on 1200 x 1024 (no interlacing)
	~25 Hz for 512 x 512 pixels at 9.3 x 9.3 mm resolution
	Higher rate for smaller capture regions. E.g. ~ 175 Hz max for 1 line readout.
Data Analysis	
Pass/Fail display	On-screen, in selectable **Pass**/**Fail** colors. Ideal for QA & Production.
Averaging	Beam dimensions
Log data and statistics	Min., Max., Mean, Standard Deviation. Up to 4096 samples
Power Measurement	Units of mW or user choice (relative to a reference measurement input)
	Fluence, within user defined area
Source to CCD Distance	~14 mm optical distance from front of ND filter to

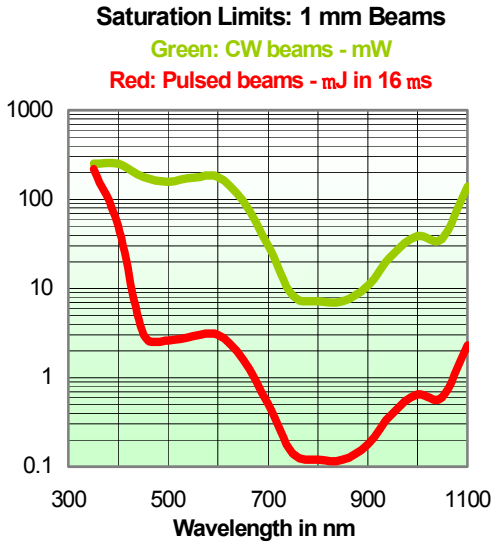
	CCD chip. Less for TaperCams. See pp. 1-10 & 1-12.
Dimensions Camera Head (See drawing)	Across axis width x Height x Along axis depth [inc. ND filter, 5.7 mm (0.23") thick] 115* x 61 x 22 mm (4.5 x 2.4 x .87 inches) *~150 mm (~6") with cable connected.
Mounting	Universal mounting block ¼-20 and M6 threaded and clearance mounting holes
Weight, Camera Head	230 gm (0.5 lb); 310 gm (0.7 lb) with Mounting block
Minimum PC Requirements (Mac version is *not* available)	700 MHz or better PC running Windows 98, Me, NT, 2000 or XP; 256 MB RAM; CD-R or RW. PCI Slot; 10 MB Hard Drive space; 1024 x 768 monitor. Notebook PC Third party adaptor. Contact us.

Maximum Power Graph

The graph allows you to simply determine the *approximate* maximum optical power that WinCamD can measure *without additional attenuation*. In both cases the **Saturation Limit** assumes:

- A $1/e^2$ (13.5% clip level) beam diameter of 1 mm
- The provided ND 4.0 filter in place
- The electronic shutter set at 16 ms, its lowest value
- The CCD amplifier gain set at 1, its lowest value
- ***The total power does not exceed 1W***

CW Laser: The **upper** (green) line is the Limit for CW Lasers in **mW**.



E.g. At 633 nm the Saturation Limit for a '1 mm HeNe' is ~150 mW.

For a 0.1 mm diameter beam the limit is 10^2 **less** at ~1.5 mW

For a 3 mm diameter beam the limit *would* be 3^2 **greater** at ~1.35 W, but since this exceeds the 1W total, the limit would be 1W.

Pulsed Lasers: The **lower** (red) line is the Limit for Pulsed Lasers in **mJ of energy within 16 ms** (the minimum shutter period).

E.g. At 1064 nm the Saturation Limit for a '1 mm Nd:Yag' is ~1 mJ in 16 ms

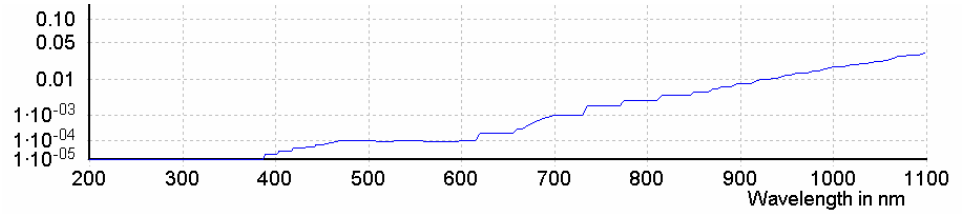
If the Pulse Repetition Rate is £60 kHz this is 1 mJ per pulse.

If the Pulse Repetition Rate is >60 kHz this is <1 mJ per pulse.

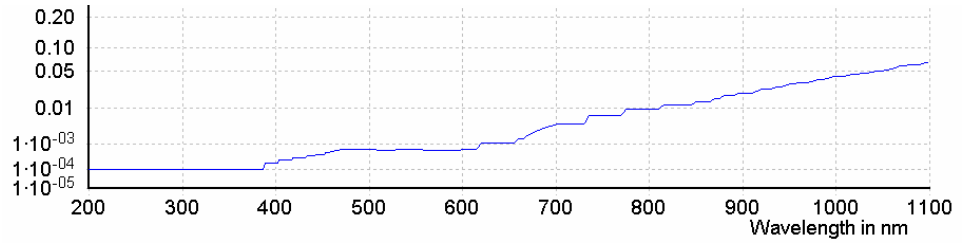
For a 0.1 mm diameter beam the limit is 10^2 **less** at ~0.01 mJ in 16 ms.

For a 3 mm beam the limit rises by 3^2 to 9 mJ per pulse … except that the 1 W limit means that the PRR must not exceed ~50 kHz.

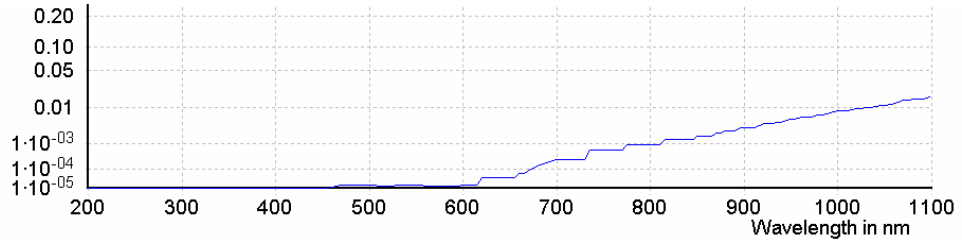
'ND4' filter transmission: nominal and range.



Nominal 1 mm thick filter



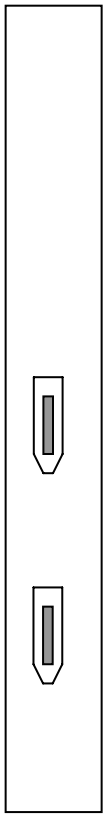
High transmission limit



Low transmission limit

PCI Card connections

1.6



Top - capture tab end

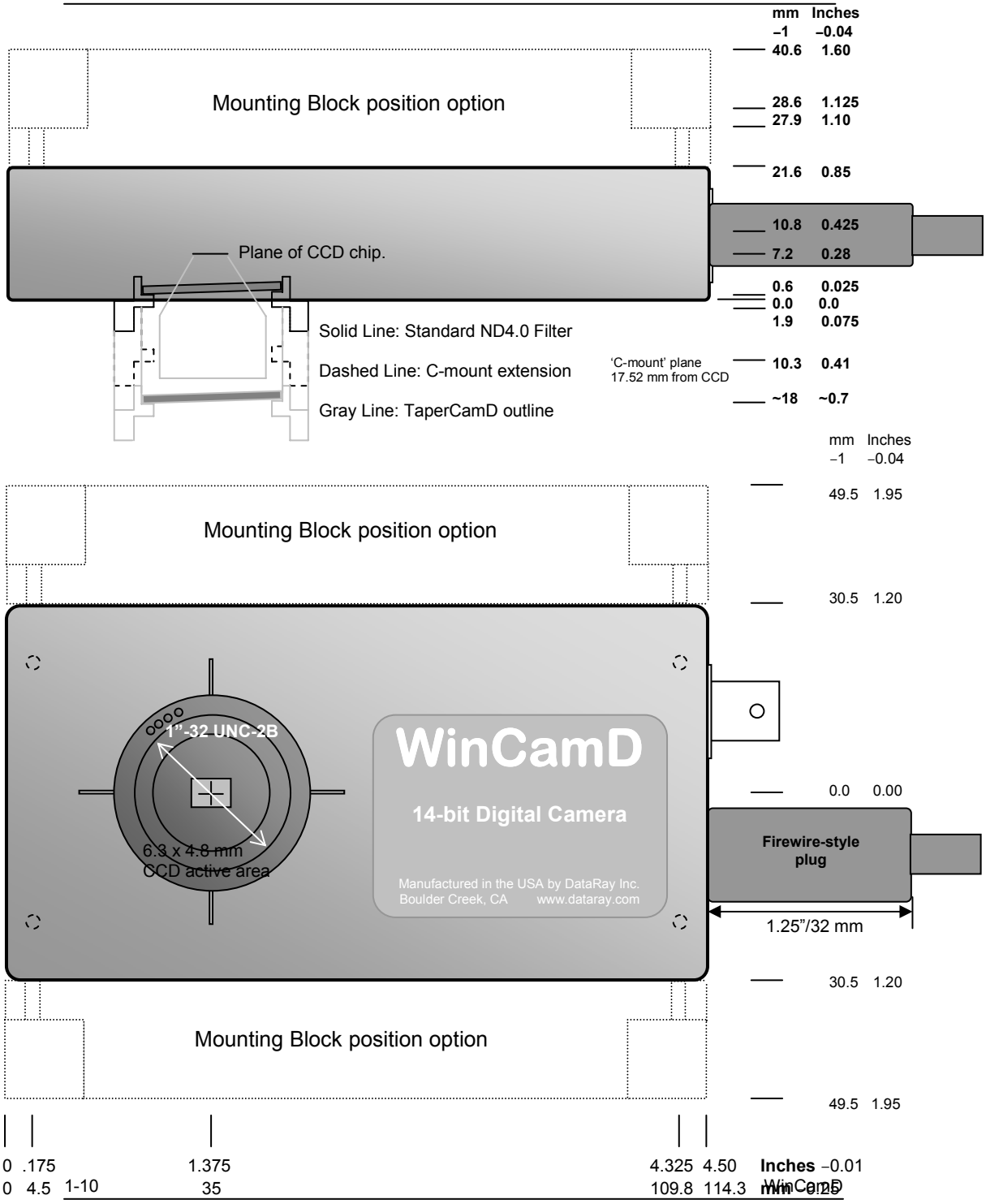
Camera Port 2

6-pin male Firewire (IEEE 1394) style physical connectors …
… but *not* Firewire electrical interface

Camera Port 1

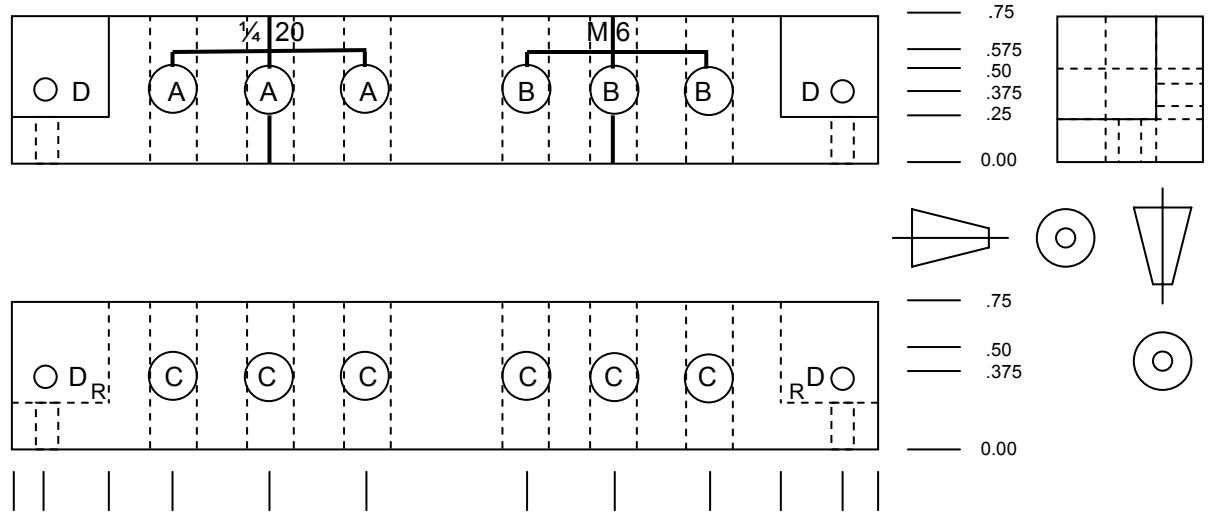
Bottom - PCI socket side.

You may use either port. Future versions will perform simultaneous image capture on both channels. Currently the image is taken by one camera or the other. Contact us.


mm Inches
–1 –0.04
40.6 1.60
28.6 1.125
27.9 1.10
21.6 0.85
10.8 0.425
7.2 0.28
0.6 0.025
0.0 0.0
1.9 0.075
10.3 0.41
~18 ~0.7
Mounting Block position option
Plane of CCD chip.
Solid Line: Standard ND4.0 Filter
Dashed Line: C-mount extension
Gray Line: TaperCamD outline
'C-mount' plane
17.52 mm from CCD
mm Inches
–1 –0.04
49.5 1.95
Mounting Block position option
30.5 1.20
1"-32 UNC-2B
6.3 x 4.8 mm
CCD active area
WinCamD
14-bit Digital Camera
Manufactured in the USA by DataRay Inc.
Boulder Creek, CA www.dataray.com
0.0 0.00
Firewire-style
plug
1.25"/32 mm
30.5 1.20
Mounting Block position option
49.5 1.95
0 .175 1.375 4.325 4.50 Inches –0.01
0 4.5 35 109.8 114.3 mm –0.25

WinCamD mounting block –actual size. Version 0201D

(Earlier version did not align with CCD axis)



Holes 'A' Tapped ¼"-20

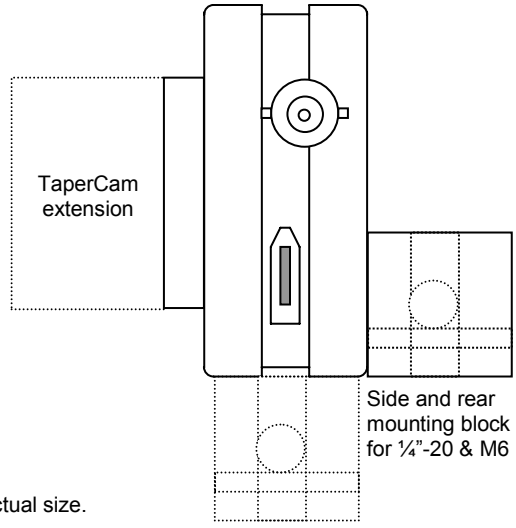
Holes 'B' Tapped M6

Holes 'C' 0.25" diam.

Holes 'D' Clearance for #4-40

Tolerances: –0.005"

Material: Black Anodized Al. alloy

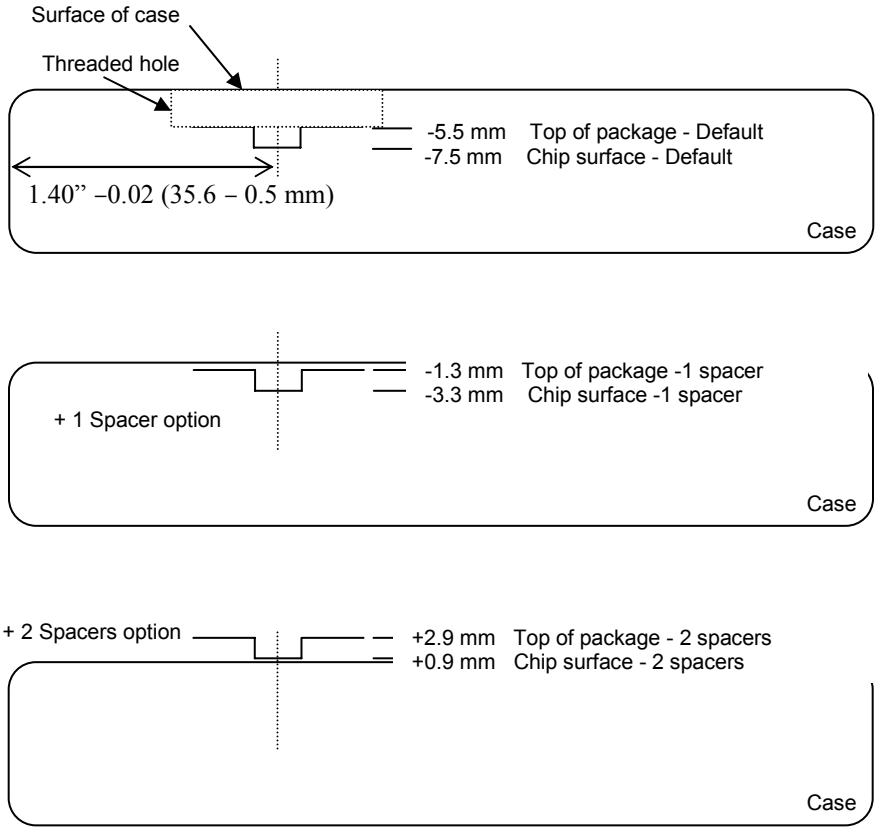


Camera shown actual size.

Chip surface height, standard and options.
All standard units have the window glass removed to avoid interference fringing with coherent sources. The chip has a protective surround above the bond-wires. This may be removed upon request, but use in this mode is at customer risk. The default height is at -7.5 mm; i.e. the standard C-mount distance of 17.52 mm, less 10 mm. If the Default option is chosen, the hole is a 1.0"-32 tpi, 'C-mount' thread.
Heights are given in mm with respect to the surface of the case. 1 mm = 0.03937" Tolerances are – ~0.2 mm typical, – ~0.5 mm worst case.

Additional 4.2 mm deep chip sockets may be added, increasing the height as shown. If the single or double height socket option is chosen, the hole is 1.30"-20 tpi.

To request a different spacer height, add **/S1** or **/S2** to the Part Number. E.g. **WinCamD/S1**
Due to the non-standard case, there is a small additional charge for these options.



1.7 BEAM LIMITS

- Regions are shown actual size.

1.7.1 Beam Measurement Region

6.3(H) x 4.8(V) mm for WinCamD and WinCamD/IR.

For accurate profile measurement, the beam to be measured must lie totally within the area shown.

For the most accurate measurements, center the beam at [x,y] = [0,0].

For true 4s (Variance) measurement to the ISO 11146 standard, the beam diameter at the 13.5% clip level, should be a maximum of half the measurement regions shown, i.e. £ 3.15 x 2.4 mm. The ISO standard also requires that five sample averaging should be performed.

The Second Moment measurement integral is truncated by the software at – twice the width at the outer 13.5% clip level. This approach is less sensitive to amplitude noise than the alternative approach of truncating the integral at a certain low clip level.

1.7.2 Beam Power Limits

Measure your beam with a calibrated power meter before letting power fall on the head.

Under any circumstances the following maxima apply.

The following head damage limits *always* apply:

- Total power on the head must not exceed 1 W, or head damage may occur.
- Beware of back reflections from the ND filter. *Always employ appropriate eye protection*.
- CCD chip Irradiance limits

l nm	*Damage Threshold*		*Saturation Irradiance*	
	mW/cm^2	mJ/cm^2	mW/cm^2	mJ/cm^2 *
355	Few	~0.3	~0.3	~0.01
630	>10	"	~0.15	~0.005
800	"	"	~0.1	~0.004
1060	"	"	~10	~0.4

1.8 MANUAL CONVENTIONS

- ‘click’ always means ‘left-click the mouse button’.
- ‘double-click’ always means ‘double-click with the left button’.
- ‘click and drag’ means ‘left-click on the object indicated, hold down the button, drag the object across the screen to the desired position, and then release the button’.
- If a right-click is required this is clearly indicated as ‘right-click’.
- ‘select’ or ‘check’ means ‘left-click with the mouse button’.
- ‘press’ always means ‘press the keyboard key’
- ‘enter’ means enter using the keyboard.

  e.g. ‘Enter **Alt F, S**‘ means ‘Press the **F** key while holding down the **Alt** key, then release the **Alt** key and press the key marked **S**’. Sometimes it is necessary to finish with the **Enter** key to complete a process.

- **10 pt. Arial Bold** indicates keyboard entry items or words etc. found on the screen.

1.9 MANUAL AND COPYRIGHT NOTICE

This manual describes the operation of the WinCamD and TaperCamD Beam Imagers. We reserve the right to make changes to this manual and to the equipment described herein without notice. We have made considerable efforts to ensure that the information in this manual is accurate and complete. However, we will not be liable for any technical or editorial errors or omissions or for any incidental, special or consequential damages of any nature resulting from the furnishing of this manual, or for the operation and performance of equipment in connection with this manual.

CHAPTER TWO

2 INSTALLATION

2.1
2.2

2.1 UNPACK THE HARDWARE

Please check your purchase. Locate and identify all items. If any items appear damaged or missing or you have any other questions, please contact us.

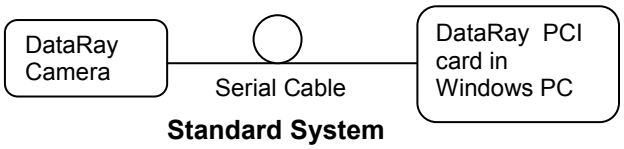
Do not unpack the PC card until you are ready to install it in the computer.

2.2 PART NUMBERS

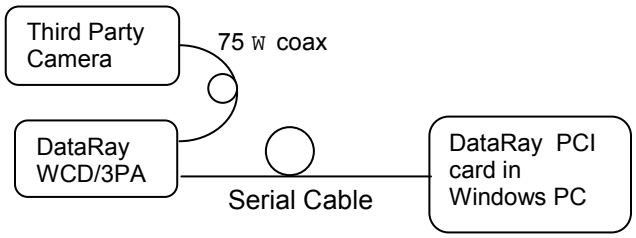
Part Number	Description
WinCamD	**Complete working system** comprising WCDBoard + WCamD
WinCamD/IR	**Complete working system** comprising WCDBoard + WCamD/IR
TaperCamD	**Complete working system** comprising WCDBoard + TCamD
TaperCamD20/15	**Complete working system** comprising WCDBoard + TCamD20/15
TaperCamD/IR	**Complete working system** comprising WCDBoard + TCamD/IR
WCDBoard	Software + PCI card + Cable + User manual (Camera not included)
WinCamD/3PA*	For 3rd party NTSC or CCIR cameras. Comprises WCDBoard + WCamD/3PA. **Not currently available or scheduled.*
WCD/3PA*	Third Party Adaptor only for NTSC and CCIR analog cameras. [75 W BNC input]. ** Not currently available or scheduled.*
WCamD	Digital CCD Camera: 6.32 x 4.76 mm active area; 4.65 m square pixels
WCamD/IR	Digital IR CCD Camera: 6.32 x 4.76 mm active area; 4.65 m square pixels
TCamD	Digital CCD Camera with FO Taper: 14.2 x 10.7 mm active area; 10.5 m square pixels

TCamD20/15	Digital CCD Camera with FO Taper: 19.6 x 14.8 mm active area; 14.4 mm square pixels
TCamD/IR	Digital IR CCD Camera with FO Taper: 14.2 x 10.7 mm active area; 10.5 mm square pixels
ND0.5 to ND 4.0	Neutral density filters in ND 0.5 steps in stackable C-mount threaded holders

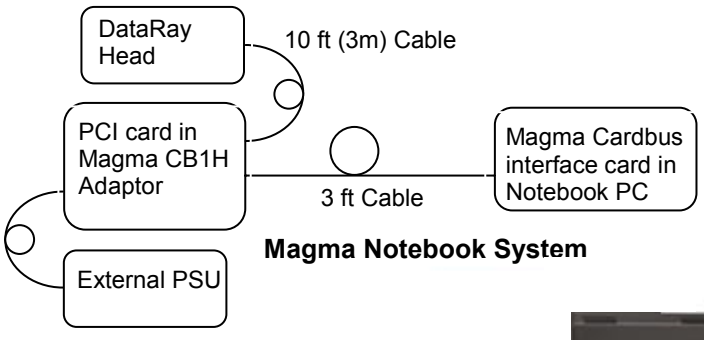
Visit the website for the latest update and details for this list.



Standard System



Third Party Camera System



Magma Notebook System

See the website or contact us for the Magma CB1H Application Note.

2.3 *MINIMUM* COMPUTER REQUIREMENTS

- **WARNING:** PC's with an unusual BIOS *may* be difficult to configure to work with the hardware. Stick with popular name brand PCs wherever possible.
- WinCamD is not available in a Mac-compatible version.
- A 700 MHz Pentium III PC or faster. *AMD processors with no integral numeric coprocessor do not offer adequate processing speed.*
- ǂ 1024 x 768 display with 256 colors
- A free ½-size PCI slot
- A Microsoft compatible mouse, preferably with a clickable center wheel
- Windows 98, Me, NT4.0 with Service Pack 5 or higher, 2000 or XP.
- ≥256 MB of RAM. A hard drive with 10 MB or more available space.
- A CD-R drive, preferably a CD-RW for exporting large files
- A 56 kbps or higher Internet connection for software upgrades, or a network connection to a PC with such a connection.

WinCamD systems employ DMA (Direct Memory Access) to place image data into the computer memory. Although these products do not use Interrupts, sometimes problems *may* arise due to Interrupt (IRQ) or I/O conflicts. The problem *may* be solved by moving the board to a different slot, [all card slots are not created equal by all manufacturers] or by looking at IRQ status by following the trail: **Desktop**, **My computer**, right-click and select **Properties**, **Device Manager**, **Properties**, **View Resources**, and look at **Interrupt request [IRQ]** or **Input/output [I/O]**.

Even though image capture and manipulation are processor intensive, problems should not occur with networked computers. If there is a problem, the normal solution is not to log on to the network when using the WinCamD.

Due to the individual PC configuration issues involved and the non-standard implementations of the 'Standards' that do exist, we can give no guarantees in solving such problems. Contact technical support.

2.4 INSTALLATION

Most installation problems are caused by not carefully following the instructions. Hardware installation is never as simple as software only installation.

If you want to save time, read and follow the instructions.

IMPORTANT: Install the software ***before*** the PC card. The software can be used to view data whether or not the PC card is installed.

Software upgrades are free for the life of the product. The absolutely latest software is ***not*** *necessarily the version shipped with the hardware.*

Always *visit* **Sales & Support**, **Software Upgrades** *at the website in order to determine whether a more recent version is available for download.* Check the version *and* the date. If you do not already have it, download the latest version of **iDataRay.exe** from the website and place it in a temporary directory named, e.g. **c:\Downloads**

- In case you need to return to an older version of the software, rename any old Dataray directory, as **c:\datarayx-xxy**, where **x-xxy** is the version number found on the top line of the opened program.
- If this is a completely new software installation you may skip the section immediately below on versions prior to 2.01A.

Important: Previously Installed Versions prior to 2.01A?

If you have a software version older than 2.01A on the PC, then due to a driver change, *unless you take the following precautions, your computer could freeze on start-up after you have installed the card*.

This would be due to a conflict between the new driver and **DriverX**, installedthe earlier version of the software. [The last version which used **DriverX** was 2.00E.]

Before installing the PCI card, restart the PC, and delete **driverx.sys** & **driverx.vxd** from:

NT & 2000	c:\winnt\system & c:\winnt\system32\drivers
95 and 98	c:\windows\system & c:\windows\system32\drivers.

All versions: **Start**, **Run …**, type in **regedit**, and press **Enter**. Then go **Edit**, **Find**, type **driverx** in the **Find what:** box and click **Find Next**. This may take some minutes. Wherever it finds a subdirectory with **driverx** references, delete it/them, and then press **Find Next** to find the next of the possibly multiple locations.

- **Windows NT, 2000 & XP**: You **must** install the software as 'Administrator'. *'User with Administrator Rights' is not enough.* [If you cannot even install the software, it may be that your Administrator (i.e. the real-live person) has restricted your software installation rights, and must therefore be called in to install the software.]

  To install this software under Windows NT, you ***must*** be running NT 4.0 with Service Pack 5 or higher. If you are at all unsure, do not waste your time but get someone who knows NT or 2000 to help you.

2.5 SOFTWARE INSTALLATION INSTRUCTIONS

These instructions assume that you are running Windows 98, Me, NT, 2000 or XP and using a PC that meets the minimum requirements listed in Section 2.3 of this manual. These instructions also assume that you are reasonably familiar with Windows.

1) The software is installed from within Windows. If your computer is not running Windows at this time, please run it now.

   Avoid *potential* installation problems, by turning off programs running in the background - e.g. anti-virus software, network connections, ICQ, Instant Messenger, automatic fax reception, etc. That said, to date such programs have given us no problems in lab tests.

2) To load from the CD, go **Start**, **Run..**, **Browse** to **d:\idataray.exe** and press **Open** and then **OK**.

   In Windows Explorer, from **c:\Downloads**, or whichever temporary directory you put it in, double-click **iDataRay.exe** to install the software.

   You *can* install over an existing version of the software. Saved measurement files will not be deleted.

   The install program will allow you the option of changing the drive and directory location of the software. The default is **c:\Program Files\DataRay** .

   Important. Currently, to put the icon on the desktop, in the **Choose Shortcut Location** you must select the **On the Desktop** option, or it will default to the **In an existing program group** option. [Amended in Version 4.XX]

3) **Install the software driver for the PCI card** as follows:

   In **c:\Program Files/DataRay**, locate **WinCamD_NT_W2K.inf**, for Windows NT, 2000 and XP, or **WinCamD98.inf** for Windows 98 and Me. Right-click the appropriate file and click **Install**. This makes the driver available for the PCI card installation.

4) At the Desktop, double-click the icon to start the program. The first time the program is run, or if a newer version has been installed, **Board not found** and …**Loading defaults** messages may appear. This is normal. Other problems? Contact us.

2.6 PC CARD INSTALLATION.

The PC card has been designed to be easy to use and easy to install. There are no switches or jumpers to set. Follow the simple steps below.

It is recommended that you work at a static safe workstation and wear a wrist strap grounded to the computer casework.

1) Shut down all programs, turn off the power to your computer & disconnect the PC power cord. Remove the PC cover.

2) Select an expansion slot for the PCI card. It is good practice to allow cards a maximum amount of 'breathing-room' for heat dissipation.

3) Remove the rear slot cover bracket, if present. Save the screw for future use.

4) If you are not working at a static safe work station and wearing a wrist strap grounded to the computer, then before removing the card from the bag, contact the pink or metallic looking static safe bubble-wrap bag to the computer metalwork. Then immediately place the card in the computer.

5) Carefully hold the card by its top edges and guide it into its expansion slot. Ensure that the card sits firmly in the slot.

6) Secure the card in place by with the screw and replace the computer cover.

7) Connect the supplied 6-pin Fire-style cable *first to the card and then to the head*.

8) Reconnect the previously disconnected PC power cords. Power up the computer.

9) When you restart the computer with the card installed, follow the screen dialog. In Windows 98, Me & 2000, ***but not NT***, it will look something like:

   New Hardware Found

   PCI bridge

   Windows has found new hardware and is locating the software for it

   Which quickly changes to: **Update Device Driver Wizard**

   You want to allow Windows to search for the driver. Click: **Next** for **Yes (Recommended)**, *but first let the computer complete its start-up for all the little*

icons at the bottom of the screen. I.E. wait until the hourglass has changes back to the normal cursor and stays that way, and the hard drive has stopped clicking.

If you get the message: **Windows was unable to locate a driver for this device.** Select: **Other Locations …** and **Browse …** to **c:\programs\dataray** , and click **OK**, then **OK** again, and then **Finish**.

NTdoes not install in the same sense, and this Wizard process does not happen.

In case your installation is slightly different, the file that you are trying to install as a driver is **WinCamD98.inf** for Windows 98 & Me, or **WinCamD_NT_W2K.inf** for Windows NT, 2000 or XP, both are found in **c:\Program Files\DataRay**.

[Note that Windows NT, 2000, XP may copy these files to the **c:\WINNT\inf** directory and rename them as **oem_.inf**.]

10) Then mount and connect the head (Sections 2.7 below) and start the software. If it does not change from **..Starting..** to **Running** in a short period, then it has not found the driver, in which case, see 11) below.

If when you start the software it comes up with **No boards found.**, then, as the screen advises, **Try one reboot**. If the same message reappears when you restart the software after the reboot, reboot it once more. If you still have no success, contact Technical Support.

11) If the card did not link properly in the first place, then at the desktop, right click on **My Computer**, select **Properties**, **Device Manager**, click on the **+** sign next to **DataRay**, and double-click **DataRay WinCamD series**.

Select **Drivers** and then click on **Update Drivers …** to get to the **Update Device Driver Wizard** in 9) above.

If the system is still not working, it can be useful to 'refind' the PCI card. In **Device Manager**, **Remove**, **DataRay WinCamD series** and then **Refresh** to allow the system to refind the card. This will take you to 9) above.

"I've done all this and it still does not work."

Although heads and cards are interchangeable, all systems are checked as a head plus card combination prior to shipping. The probability that one of the components is not working is extremely low. If it still does not work, the most likely explanation is that you accidentally skipped one or more instructions. Proceed as follows:

- Go **Start**, **Settings**, **Control Panel**, **Add/Remove programs**, **DataRay** and uninstall the software.
- Delete the card in **Device Manager**, and then power down the computer and take out the card. Reboot the computer and then shut it down again.
- Sometimes, though rarely and for no good reason, using a different PCI slot can help.
- Reread the instructions carefully, and start again from scratch.

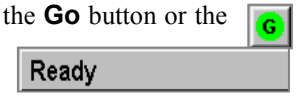
  If you are still unsuccessful, contact Technical Support.

2.7 MOUNTING THE HEAD

1. See the mounting detail towards the end os section 1.6. It is recommended that you mount the head before you connect it.
2. Since the sensitive area is only mm in dimension, ensure that either the head or the source assembly can be adjust in x, y and, as necessary, z.
3. Mount the head off the mounting block.

2.7.1 Connecting the Head.

1. With WinCamD you can 'hot' plug or unplug the head without damaging it in any way.
2. Connect the 3m (10 ft.) 6-pin Firewire-style cable between the head and the PC card.
3. Start the PC if it not already started.
4. Start the software. To start taking data press **F1**, click on the **Go** button or the **Ready** button, or press **g** on the keyboard.



5. If you try to start taking data with no head connected, you will get the message **No camera detected!** .
6. If you try to start two copies of the program, it should not happen. In some instances the message shown will appear. Click **OK** and then find the copy that you have already opened on the task bar at the bottom of the screen.

Congratulations. You have successfully completed installation.

"I've done all this and it still does not work."

Although heads and cards are interchangeable, all systems are checked as a head plus card combination prior to shipping. The probability that one of the components is not working is extremely low. If it still does not work, the most likely explanation is that you accidentally skipped one or more instructions. Proceed as follows:

- Go **Start**, **Settings**, **Control Panel**, **Add/Remove programs**, **DataRay** and uninstall the software.
- Delete the card in **Device Manager**, and then power down the computer and take out the card. Reboot the computer and then shut it down again.
- Reread the instructions carefully, and start again from scratch.

If you are still unsuccessful, contact Technical Support.

2.8 LABVIEW™, LABWINDOWS, VISUAL BASIC, VISUAL C++, DLL'S.

See **Dll's and Interfacing for DataRay Products**, downloadable from the website. Version 4.XX and higher will feature an OCX architecture which will allow simultaneous operation of the screen display and the interface to other software. It is recommended that any new interfacing be based on Version 4.00X or higher.

2.9 FIRMWARE UPGRADES

- **What is Firmware?** Firmware is software code that resides in the hardware rather than 'running' on the PC. Upgrades may be required to improve performance, add features, and/or to correct a bug.
- **How frequent are upgrades?** Firmware upgrades *may* happen a few times during the first year following introduction of a new product or a major hardware upgrade. Subsequently they are rare events.
- **How do I know if an upgrade is available?** Go to the website, and under **Sales and Support** look for **Upgrades**, **Firmware**. As we develop this feature, you may receive an email notification.

You may download the **Firmware Upgrades to DataRay PC cards** Application Note from the **Sales and Support** area of the website.

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CHAPTER THREE

3 QUICK-START TUTORIALS

If there is no PCI card in the PC, then when you press **Go**, the software will change from **Ready** to **Demo** loading, and will generate a Gaussian beam with superimposed noise. You may then use this beam to experiment with, even if you cannot capture images.

Do not just read this User Manual. *Do* sit at the computer and try out the software.

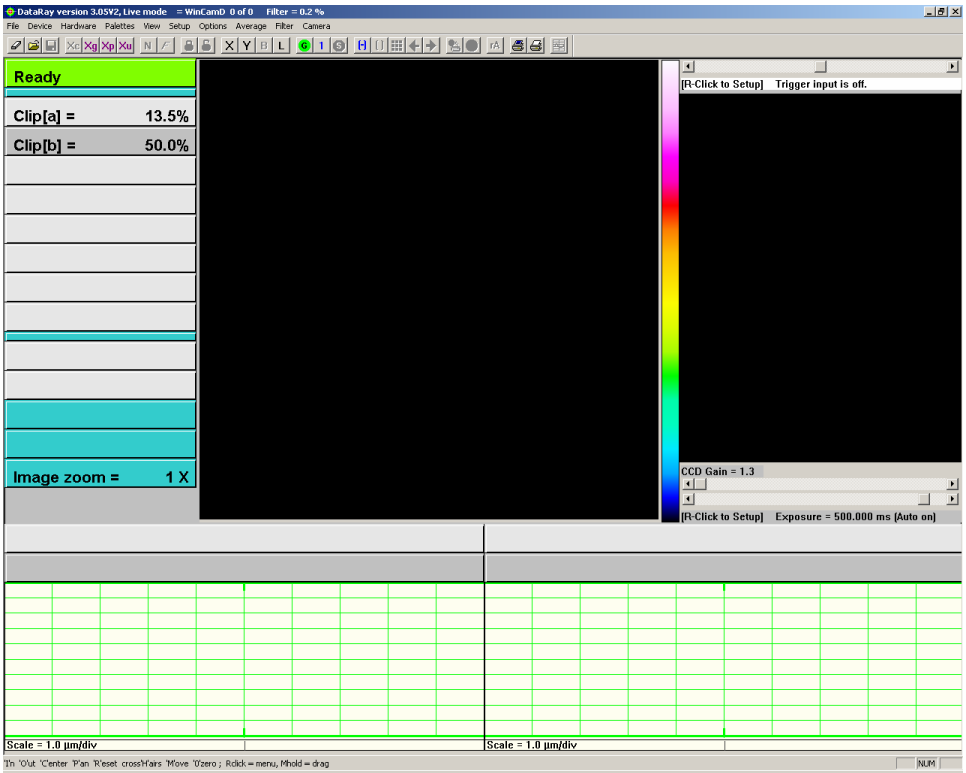
- ❑ Unfamiliar with the hardware, or just evaluating the software? Start at Section 3.1.
- ❑ Familiar with the software but never used the hardware? Go to Section 3.6.

3.1 MAIN SCREEN

3.1.1 Start the Software

Double-click the icon to start the software. [See Chap. 2 if software is not yet installed.]

If the PC card and/or a head is not present, a warning will appear. Click **OK**. In the pull-down menu, under **Device**, select **WinCamD**. For TaperCamD series, select WinCamD and then set the Pixel Multiply Factor, Sec. 3.3 page 3-25. The WinCamD main screen

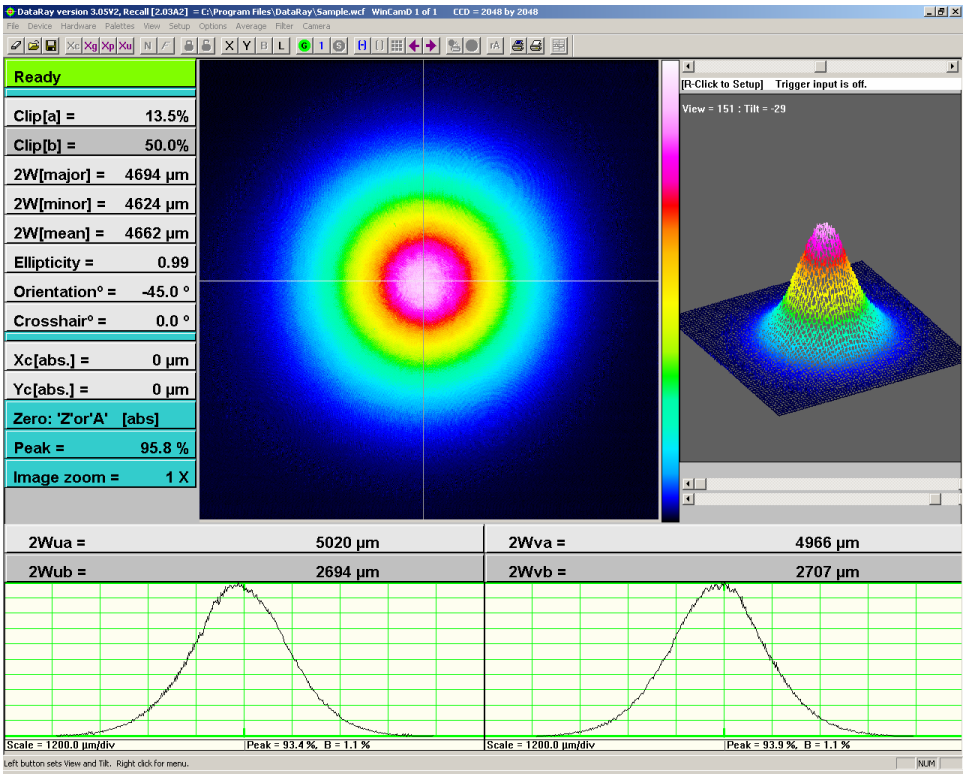


default display shown below should appear.

3.1.2 Examine Previously Saved Data

Click on this button, or enter **Alt F, O** , to open the **Open** dialog box.

Select **Sample.wmf** file, and click **OK** to see a screen similar to that below. As software upgrades occur, the detailed appearance and/or the initial settings may change.



When you simply open an image it *does not* change the current settings of the various display and measurement options.

It is possible to change these settings as a group by saving an acquired image with specific display settings as a ***.job** file and then opening this file which contains display and analysis settings. See Sec. 3.3.1.

3.1.3 Main Screen Top

- The blue streak of **Caption bar** at the top displays:

  - **DataRay version 3.05x,** The software version on your PC.
  - **Recall [N.NNx]**. The the Rev. of the software employed to save the recalled file.
  - **WinCam[C:\Program Files\DataRay\Sample.wcf]**. The file currently displayed.
  - **Profile 1 of 8**. The profile number 'i of n'.
  - **Filter = 0.2%**. The current profile filter setting.

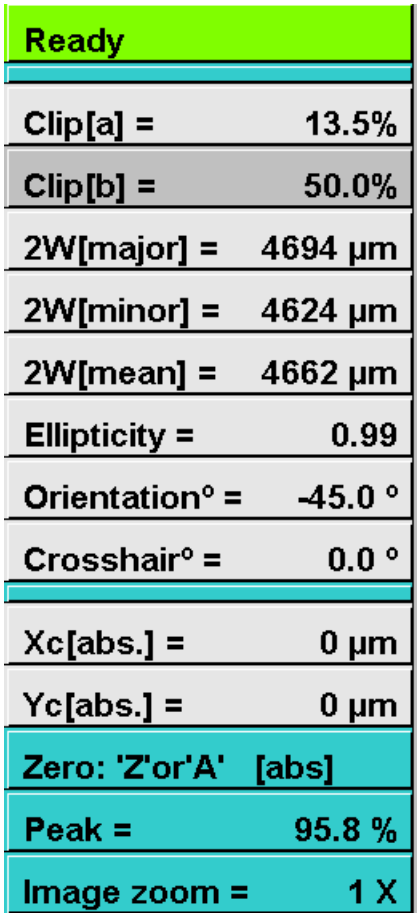
- **Pull-down Menus** – have a quick look. Note the existence of keyboard short-cuts. Section 3.2 describes the pull-down menus in more detail.

- **Toolbar**: Accesses frequently used functions. Sec. 3.3 contains detailed descriptions.

  If you have no PC card installed and are simply evaluating the software, then a number of buttons will be grayed out.

  Hover the mouse over any button to see a description of its function. If additional buttons appear in later software revs, hover the mouse over them to determine their function.

3.1.4 Main Screen Left Hand Side.



- The top line is the current head status, either **Ready**, **…Starting…**, or **Running**.
- **Clip levels** User set profile clip levels that determine **2Wa** and **2Wb**. See also Sec. 3.2.3.

  2w[major] = xxx mm
  2w[minor] = xxx mm
  2w[mean] = xxx mm
  These diameters are calculated about the beam centroid for the total image, whether or not the beam appears cicular.

  The **minor** axis is calculated as the center of the 45° sector that contains the smallest mean diameter at the specified Clip[a] level.

  The **major** axis is defined at 90° to the minor axis.

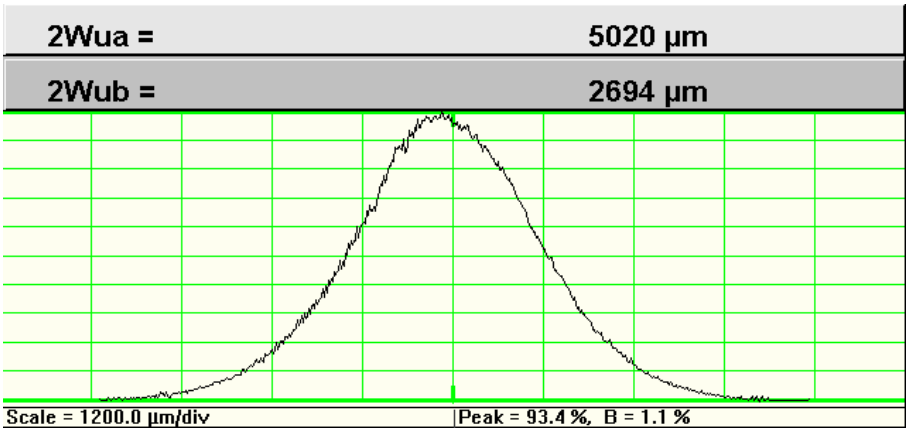
  The **mean** diameter is the mean for the whole beam. Note that it may be higher than than the minor or the major values. If this seems not possible, consider a rectangular beam and the answer becomes clear.
- **Ellipticity** = **2w[minor]** / **2w[major]**
- **Orientation° = xx.x°** is the orientation of the major axis of the ellipse with respect to the horizontal x-axis.
- **Crosshair = xx.x°** is the angle at which the crosshairs are currently set.
- **Xc[abs.] = xxx mm** & **Yc[abs.]** (or **[rel.]**) are the beam centroid positions. These are determined using all pixels in the image above the specified level. The default is 13.5%. See Section 3.3 for how to set alternative levels.

  Zero: XY: 'Z' or 'A'bs. is a button that toggles between Absolute centroid and Relative centroid. [Pressing **Z** or **A** on the keyboard gives the same result.] Selecting **Z** resets the relative centroid [0,0] to the current centroid position.
- **Peak = xx.x%** is the image peak level as a % of the ADC range.
- **Image zoom = N X** is the current 2D and 3D screen zooms.

3.1

3.1.5 Main Screen Profile Display

- **2Wxa** & **2Wxb**: These are the profile widths at the **Clip[a]** & **Clip[b]** levels.
- **Zero level**. First note that the zero level is a three pixel wide line. The center is the actual zero set by the software after subtraction of the baseline. The line is set five pixels above the base of the graph area so that negative noise remains visible.



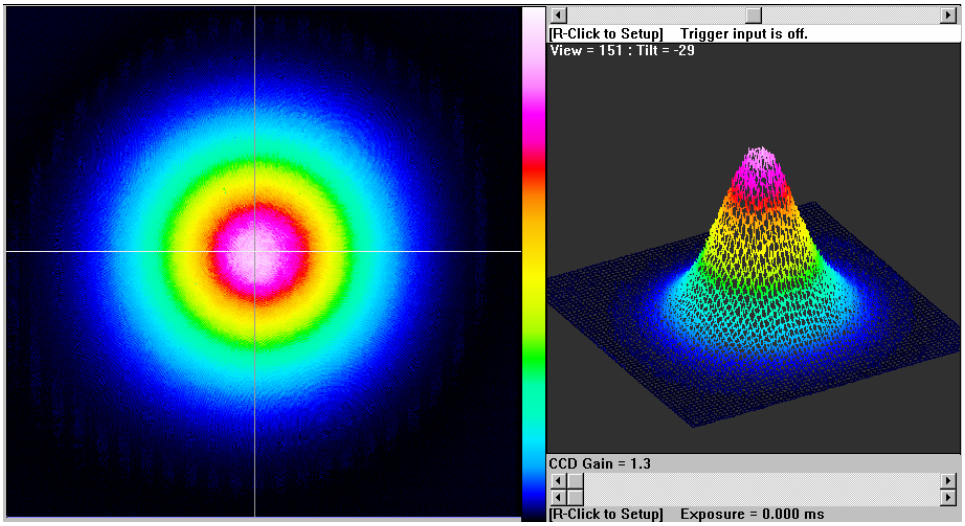
  The zero level is calculated by taking the maximum filled level of the histogram of intensities below 25% of peak. Default mode is background subtraction. To set a different zero level, see Section 3.3, **Offset**.

- **Profile Scaling**. **Scale = xx.x µm/div** for the current Zoom setting. **Zoom = 2X** indicates horizontal zoom on a profile. (Blank if not selected). The scaling at **x1** is set automatically by the program
- **Peak = xx.x%**. Indicates the peak value of the (unnormalized) profile as a percentage of the 14-bit (16,392 levels) ADC range.

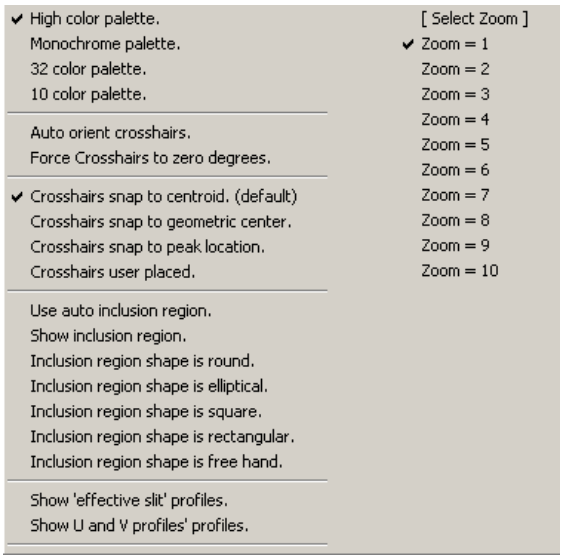
3.1.6 Main Screen Bottom Line.

- **Status Bar Help Hints**. ***VERY USEFUL*** but much ignored. Almost every area of the screen is a 'Button' which you may left-click or right-click to cause something to happen. Watch the Help Hints change on the Status Bar at the bottom of the screen as you move the cursor across the screen. Instructions for using the current function appear here. E.g. for the profile area. *If at any time you are not sure how to do something, move to the relevant area of the screen, look at the Help Hints bar, and you will often find your answer.*

3.1.7 Main Screen 2D and 3D Display Area



Right-click on the 2D area to open the box below. This allows you to:



- Change the palette selection. Now includes Inksaver option for printing - see Sec. 3.2.11.
- Auto-orient the crosshairs, force them to 0^{o}, or *if neither is checked*, allow the user to set the crosshairs by clicking and dragging on the outer portion of a crosshair.
- Set the position of the intersection of the crosshairs. These are paralleled by buttons in the button bar.
- Set an inclusion region for image acquisition. For **Use auto inclusion region.** the software will determine and uses an elliptical inclusion region that includes 99% of the energy in the image. (Not yet implemented in current version.)

- **Show U and V profiles.** superimposed over the 2D area.
- Zoom the 2D profile area, **x1** to **x10**. Pressing **i** and **o** (for 'in' and 'out') on the keyboard has the same effect.

3.2 MANIPULATE THE IMAGE AND PROFILE ANALYSIS

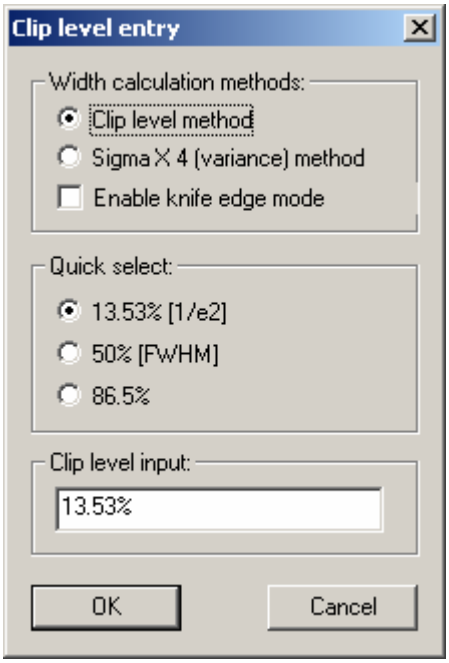
This takes you beyond the defaults described in Section 3.1.

3.2.1 2D & 3D Display & Manipulation

In the menu bar, go to **View** and **Show 3D**, to see a 3D version of the 2D reconstruction.

- Right-click on the 2D image area to bring up the Zoom and color palette options. Choose a higher Zoom setting to zoom the 3D image. The sample file is shown above.
- Right-click the 3D image and a floating menu appears. Experiment. **96 wires** is normally overkill. **64 wires** are normally enough. **Solid** is visually best, but is processor intensive and can slow the update rate on slower PCs..
- Click and drag in the 3D box to change the view of the 3D image. Side-to-side motion rotates the image. Up-down motion changes the tilt angle.

3.2.2 Choose a Beam Width Definition.



- Click on the **Clip[a]** or **Clip[b]** 'button' to open a **Clip level entry** dialog box that allows you to choose a Beam Width definition.
- **Clip Level** set at **13.5%** ($1/e^2$) is the commonly employed 'de facto' standard. (Actually 13.53%).
- 'Standard' clip levels of 1/e2 (13.5%), FWHM (Full Width Half Maximum, 50%), or 86.5% can be selected from the menu.
- *Any* user set percentage ǂ0.5 % can be entered in the **Clip level input** box.
- If ISO 11146 compliant **Sigma X 4 (variance) method** (Second Moment) is selected, the clip level is ignored. With a beam profile that is a pure Gaussian, the Variance definition is *exactly* the same as selecting a 13.5% Clip Level, but if your beam is non-Gaussian, and most beams are, the Variance method may be more consistent. An exception to this general rule is that the presence of a significant background level or background noise will skew the Variance reading to larger values.

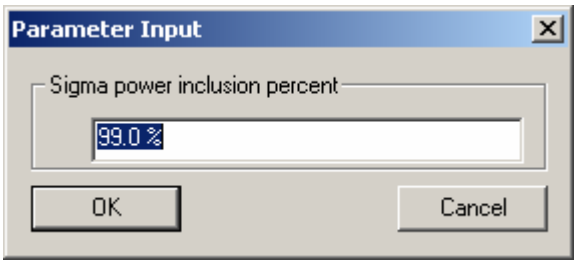
  For full ISO 11146 compliance, select Average %, see Section 3.3.2.

- In accordance with Section 6.2 of the ISO 11146 Standard, the software calculates the Second Moment by integrating over 99% of the total energy in the profile. In order to allow for any baseline tilt, the zero levels on either side of the center are treated separately and integration from the centroid is separately performed for 99% of the energy on each side of the centroid. See Section 3.5 of Appendix B for Beam Diameter definitions. For a broader discussion on Variance, see Appendix B, Sec. 4.
- **Beam Angular Divergence**. In Version 4.XX and higher, the Clip level entry will include an Angular Divergence option in °, mrad., rad, or NA.

  You will need to enter the distance in mm from the source to the camera chip. Remember that the camera chip sits 7.5 mm below the surface of the camera body.

  The software automatically performs a $\cos^3$ correction the data to allow for the use of a flat measurement plane to measure a spherically diverging beam.

Ctrl Alt S pulls up the **Parameter Input** box shown. This allows you to set a different integral energy calculation percent. If you change this, the calculation is no longer ISO 11146 compliant. You may use this facility to exclude energy in the wings or in structure distant from the main beam. Once you get away from the 99% default value, it is your call what is appropriate - we cannot provide advice on the appropriateness or not of alternative percentage settings.

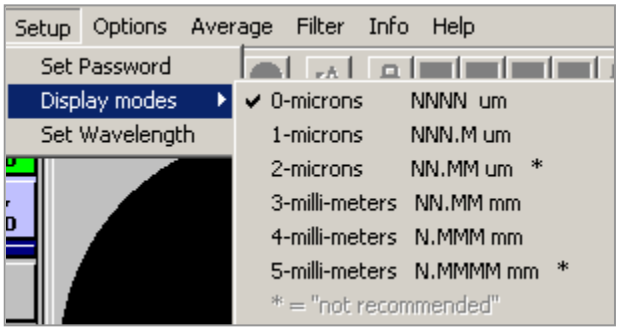


3.2.3 Set Diameter Display Mode

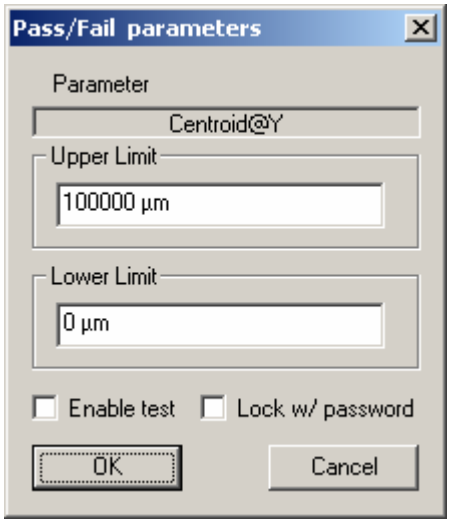
- Under **Setup** choose **Display** modes.

  1-microns NNN.M um is a common choice.

  If you decide to choose **2-microns NN.MM um *,** then heed the *** ="not recommended"** warning. [The second decimal place is <1% of the smallest pixel and is essentially meaningless … but a customer wanted the option, so …]



3.2.4 Set Pass-Fail

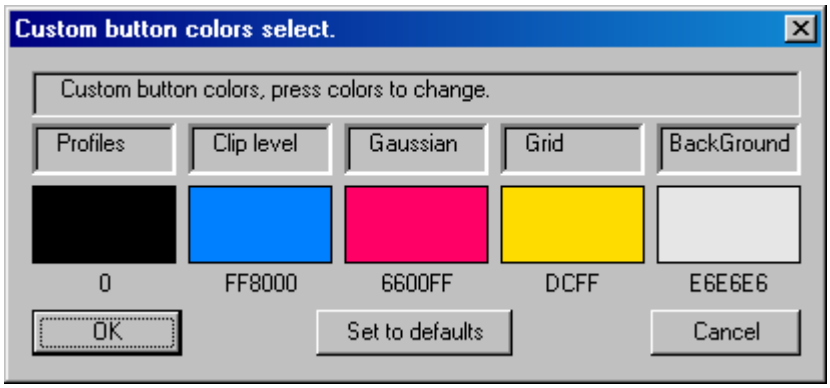


- Left-click on any result area of the screen to open a **Pass/Fail parameters** dialog box. You may set an **Upper Limit** and a **Lower Limit** for the particular parameter.
- Check the **Enable Test** box to enable the test.
- When the test is enabled, the numbers will be displayed on-screen in the chosen Pass/Fail colors. The default colors are Green for Pass and Red for Fail. Right click on a result to change these colors. See 3.2.5, below.
- Check the **Lock w/ Password** box to lock the criteria. The box below appears. ***Remember the Password.*** It you change it, it cannot be retrieved.

If you put in the wrong password, the box shown right will appear. At the time of writing, the master password is ' **peanuts** ', all lower case. If at some later time this does not work, contact Technical Support.

- Right-click on any result area of the screen to open **Custom button colors select** dialog box. Unless you have good reason, or good color sense, it is suggested that you stay with the default values.

  If you are using laser glasses, select colors which maximize the visual contrast while wearing those glasses.

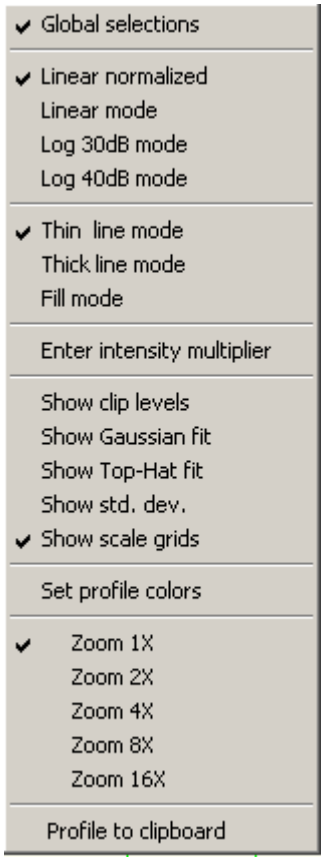


- Note particularly that:

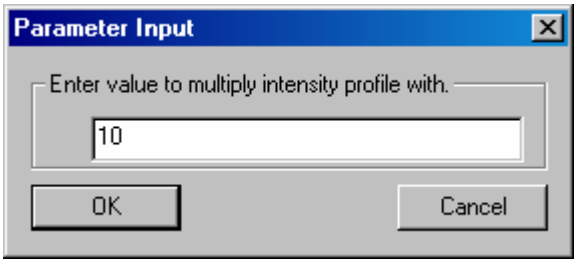
  If the software determines or suspects a result to be invalid for whatever reason, the numbers will appear in gold (yellow-orange). An example of 'determines' is when the profile peak is >100% (saturated) or <10%; in either case, the results will appear gold as a warning.

  If you wish to highlight a particular set of numbers, consider changing the background color. Ensure that it is not a color that is too close to the text and/or pass/fail colors, or the visual contrast will 'wash out'.

3.2.5 Change Profile Display



- Right-click on any 1D profile area to open the display selection box shown here. Defaults settings are as shown.
- Checking **Global selections** applies the selected items to all the profiles.
- Choose **Linear** or **Logarithmic** profile display modes. Both linear modes set the baseline to zero to compensate for ambient lighting and preamplifier offset on a dynamic basis. **Linear normalized** normalizes the profile to 100%, and is the default display mode. **Log** modes are useful for assessing structure and ghosts in the wings.
- Choose between **Thin Line, Thick Line** and **Fill mode** to choose how the profile is displayed. The latter modes are particularly useful when adjusting a laser assembly and observing the display monitor from across the test bench, or when saving the screen data for a presentation.
- **Enter Intensity Multiplier** opens the box shown which allows you to superimpose a magnified profile over the current profile. The multiplier may be any integer between 2 and 200. The legend **Profile * XX** will appear next to the red profile.



- **Show clip levels** through **Show scale grids** allow you to control how 'busy' the display appears. Uncheck what you do not need.
- When **Show clip levels** is selected, the variable clip levels are shown in blue on the profile. In future versions of the software you will be able to click and drag the levels shown on the screen.

❑ **Show Gaussian fit**. A **Gfit** results line appears over the **2w** results and a red line Gaussian appears superimposed over the profile. The Gaussian fit is based upon:

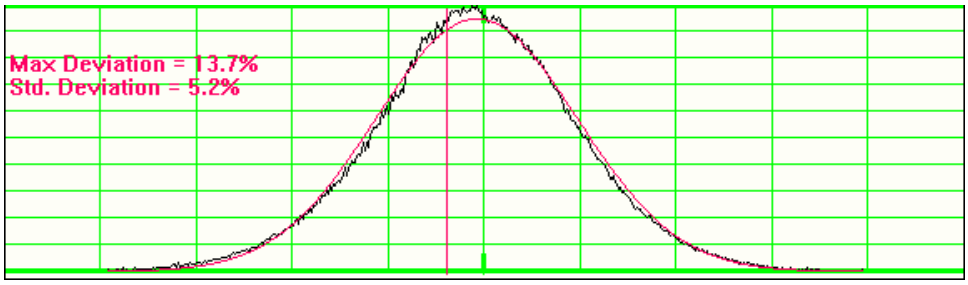
- Based upon an iterated linear fit about the 13.5% diameter.
- With a centroid the same as that of the beam.
- With the area under the curve is the same that of the beam
- Over a width that includes 99% (default) of the power in the profile. As with the 4σ diameter, **Ctrl Alt S** allows you to set a different percentage for the included power.
- The automatic fit is achieved by iteratively adjusting the height and width of the Gaussian until the Least Squares difference between the actual profile and the Gaussian profile is minimized.

  The %fit is currently calculated as:

  [1 - [(Sum of absolute differences)/(Gaussian profile area)]] expressed in %.

□ **Show Top-Hat fit** The Top Hat fit:

- Determines and subtracts the baseline. (True for all modes of operation).
- Determines the '50% of peak' edges of the profile. Defines the center (as opposed to centroid) of the beam as the midpoint between these two points.
- Determines the Least Squares level of the central 80% of this region. It plots a straight line at this mean level, and defines it as 100% for the purpose of subsequent TopHat fit calculations.
- Shows the Top-Hat fit in % as: 100[1- (Total area of |deviations|/Area under line)].



□ **Show std. dev.** For both the Gaussian and Top Hat fits, a vertical red line appears on the graph at the point of maximum deviation, and the **Max Deviation** and **Std. Deviation** are overwritten in red on the graph.

See Sec. 3.3.7 for a choosing fit options up to $TEM_{3,0}$.

TIP: On slower PCs, to speed up the processing, do not show these options.

- **Set profile colors** allows precisely that. You can waste infinite amounts of time playing with this.
- The **Zoom 1X** to **16X** allows you to zoom the profile area on which the cursor is currently sitting. If **Global selections** is checked, then all profiles will change,

  TIP: Pressing '**i**' and '**o**' on the keyboard zooms the profile 'in' or 'out' respectively, and is much faster than accessing the menu.
- **Profile to Clipboard** sends the profile on which the cursor is sitting to the Clipboard.
- **Other profile manipulation features**:

  Center profile. In order to center the profile in the profile area *in which the cursor lies*, press '**c**' for 'Center' on the keyboard

  Pan profile. In order to pan the profile in the profile area *in which the cursor lies*, press '**P**' for 'Pan' on the keyboard and the current cursor position in the profile box will be centered in the window. E.g. place the cursor to the left of the profile and when you press '**p**' the profile will move right.

  Pan image. In order to center a part of the image in the image area, *place the cursor on the part of the image that you wish to be centered*, and press '**p**' for 'Pan' on the keyboard.

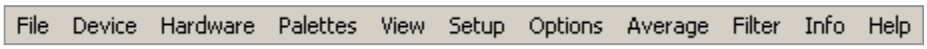
  In live mode only, and if the Capture Block is less than 1024 x 1260, if you have a center wheel on your mouse, click and hold down the center wheel and drag the image under the cursor to where you want on the screen.

  Measure any distance on a profile. Click and drag a line between two features in the profile, in order to determine the (horizontal) distance between these features. This is shown as **Dist. = xx.x mm** on the bottom left of the table below the profile. Left click in the profile area to delete the line and the measurement.

3.2.6 Gamma correction

See Section 3.6.

3.2.7 Pull-down Menus

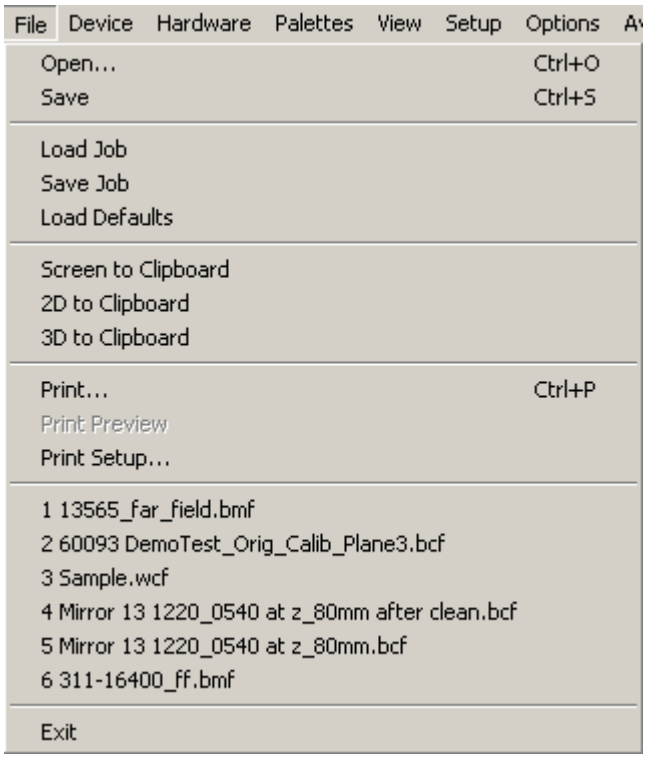


The majority of the pull-down menus are only applicable to live sessions, but it is important to take a look at them and read the brief description to understand the versatile intuitive nature of the software.

If an item in a pull-down menu appears grayed out, it is non-functional either because of the chosen mode, or because it is inapplicable to the particular head connected, or because no hardware (head or card) is present.

3.2.8 File

Where there is a corresponding button on the button bar, it is illustrated below.



- **Open… Ctrl+O** Opens the **Open** dialog box for files. 
- **Save Ctrl+S** Opens the **Save As** dialog box for files. 

  Save current data saves the current on-screen profile/image.

  SELECT data from data buffer as WCF. opens a **Beam Select Dialog** box that allows you to select which profiles to save. Click on an image to deselect it, at which point a cross appears on the image.

  SAVE ALL data in data buffer as WCF. saves all the profiles in the buffer. Be warned that a single 1024 x 1024 image gives a 2MB image. Saving multiple images can lead to a very large file. If you are going to email files elsewhere, consider collecting files over a smaller area or at a lower resolution, and/or zipping the files prior to sending them.

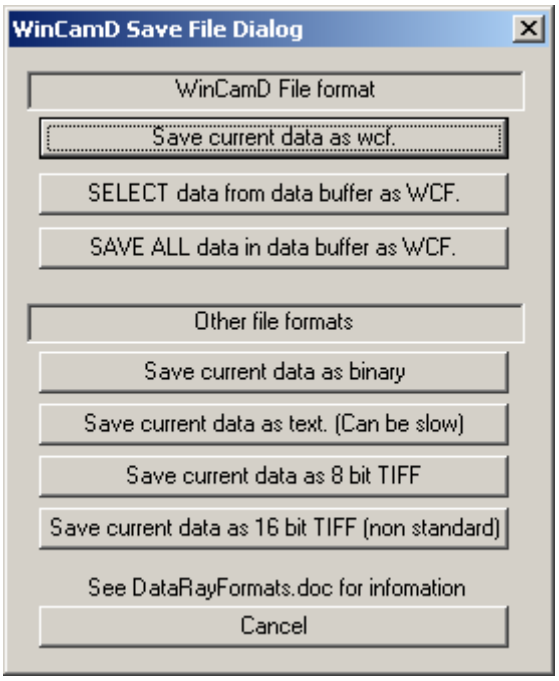
  If you select the **Attach notes** function, a dialog will open that you can fill in. When you save the file the Notes will be saved with it, and will **Print with notes** when you select that function.

Save current data as binary does precisely that.

Save current data as text. (Can be slow) saves a file in text format. These files may be imported into programs such as Excel using **,** and **;** (comma and semi-colon) as delimiters.

Save current data as 8 bit TIFF does precisely that.

Save current data as 16 bit TIFF (non standard) does precisely that. Note that there is no standard 16-bit TIFF format. These files do successfully import into Windows Paint. In **c:\Program Files\DataRay** read **DataRayFormats.doc** and follow the links in that document.



Saving Images as *.jpg or *.gif files.

To save images as ***.jpg** (JPEG) or ***.gif** (Graphics Interchange Format) files, the simplest way is to use the **Screen to clipboard**, **2D to clipboard**, **3D to clipboard** or **Graph to clipboard** features in the DataRay software, and then paste them (**Ctrl V**) into Microsoft Paint, found under **Start**, **Programs**, **Accessories**, **Paint**.

Within Paint, use the **Save As…** then **Save as type:** features to save as JPEG or GIF formats. (For some reason, not all versions of Paint support this – sorry.)

- **Load Job** and **Save Job…** A Job file allows saving and opening particular software setups. It is especially useful when testing a variety of laser assemblies on a regular basis. Saving a complex setup with specific Pass/Fail criteria is a very effective way of saving time and establishing parameters for repeatable results. Multiple *.job files can be saved, each with a different set of settings.
- **Load Defaults** does precisely that, useful if things seem 'screwed up'. Holding the **Shift** key down while starting the software has the same effect.

Screen to Clipboard sends the screen area between the Toolbar and the Status bar to the clipboard, allowing import into reports generated in other software. **2D to Clipboard** & **3D to Clipboard** send these areas to the clipboard. [**Profile to clipboard** is accessed by right clicking on the profile area.]

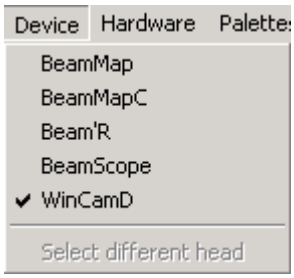
- **Print… Ctrl P**, **Print Preview** and **Print Setup…** are self-explanatory. The software will print the current screen, plus the date and a **BeamMap screen plot** title.

- **Print with Notes** allows you to do precisely that.

- The next block shows the names and paths of the six most recent files that have been saved and/or opened. Where no file path is shown, then the file is in the **c:\Program Files\DataRay** directory.
- **Exit** does precisely that.

3.2.9 Device

- Select the hardware that you are working with.
- At the time of writing, **BeamScope** is supported by the **iDataRayP7.exe** version of this software.

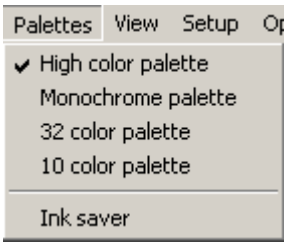


3.2.10 Hardware

These options have no effect in WinCamD.

3.2.11 Palettes

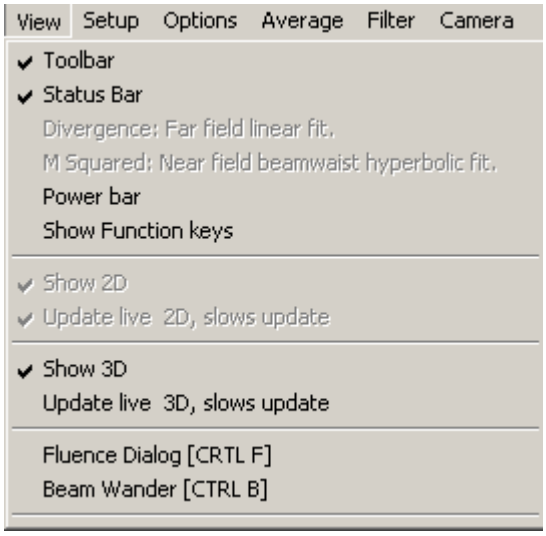
Select the palette that you require.



- High color palette is 128 color.
- **Monochrome palette** is 128 level gray scale.
- **16 color palette** is precisely that
- **10 color palette** is precisely that
- **Ink Saver** mode, changes the black and blue-black background (the lowest 2% of the levels after background subtraction) to a white background. This does what it says. It saves ink when you print, and minimizes that soggy floppy paper feeling.

3.2.12 View

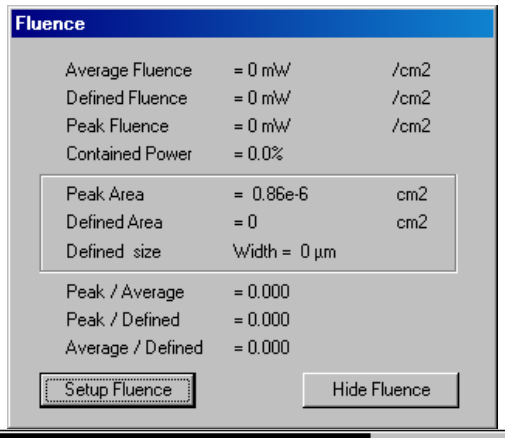
Allow you to select what is occupying the screen. Some options may be grayed out if they are not available for the system that you are using.



Useful if you have set up for production test and do not want to offer access to certain functions [or to confuse people with the 2D/3D displays with scanning slit instruments]. Set the screen up as you wish and then save it as a ***.job** file with a password.

Also useful in the unlikely event that you are working with a 600 x 800 or lower resolution monitor, and you wish to reduce what you are trying to display on screen.

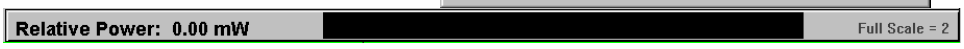
❑ Fluence

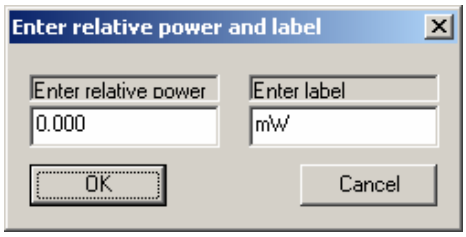


From the **Options** menu, select **Show Fluence Dialog [CTRL F]** to open the screen shown.

If it is not already open, the **Power Bar** will open. [See section 3.2.12 for full details.] You need to enter a value before the Fluence can work. Click anywhere on the Power Bar to open the dialog box shown.

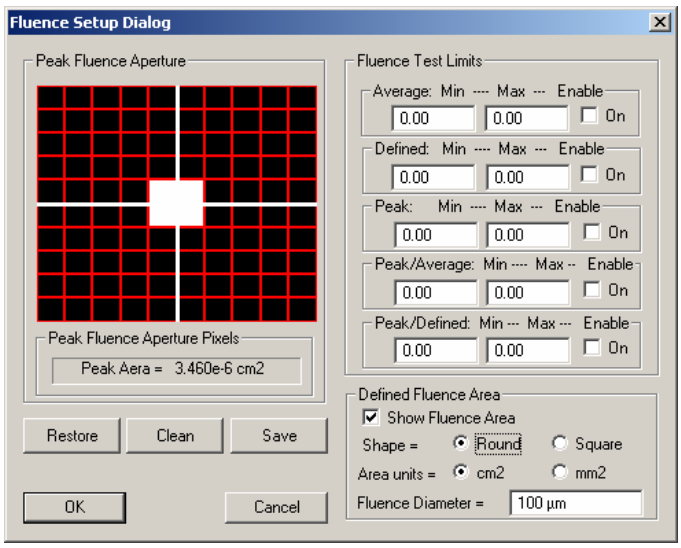
Enter the power as measured by a calibrated power meter, and the unit of measurement. The power bar will then display relative to the measurement entered.





If you enter **dB** or **dBm**, it will recognize these terms and work in logarithmic mode. You may also enter **100** as the number and **%** as a label to give answers in %.

Press the **Setup Fluence** button to open the second screen shown below.



Choose: **Round** or **Square Defined Fluence Area**; enter the **Fluence Diameter** and **Area units** that you require.

Check the **Show Fluence Area** box to show the fluence area on the main 2D screen as a white circle or square.

The default area for the **Peak Fluence Aperture** is shown on the red grid screen. Click on the grid to add pixels to the defined four pixel square shown.

To save and use what you define, press **Save**. To return to the four pixel square, press **Clean**. To restore the area that you previously created, press **Restore**.

You may also enter values and **Enable** Pass/Fail testing of **Fluence Test Limits**.

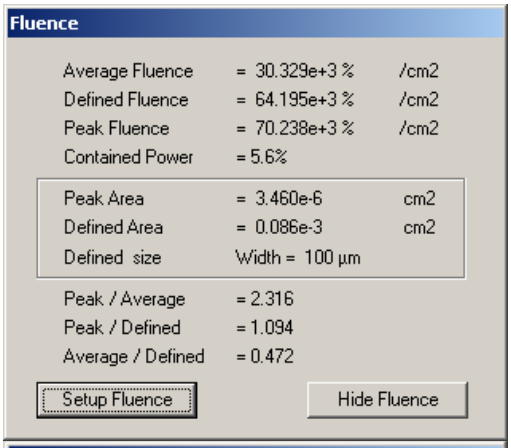
Finally, click **OK**.

Peak and **Average Fluence** appear on the main screen below the **Image Zoom =** box.

Press **Hide Fluence** to minimize the **Fluence** box.

Fluence(Pk) & **Fluence (Av)** remain on-screen on the Left hand side of the screen, below **Zoom**.

Pres **Ctrl F** again to delete the **Fluence** box. Upon exiting, the settings are retained for next time.



❑ Beam Wander

View now includes a beam Wander display, accessed from the **View** menu or by pressing **Ctrl B**. Press the **Hide** button to do precisely that, or press **Ctrl B** again to close the box.

In the future this will be tied into the log data and graphing facility described lower down in this supplement.

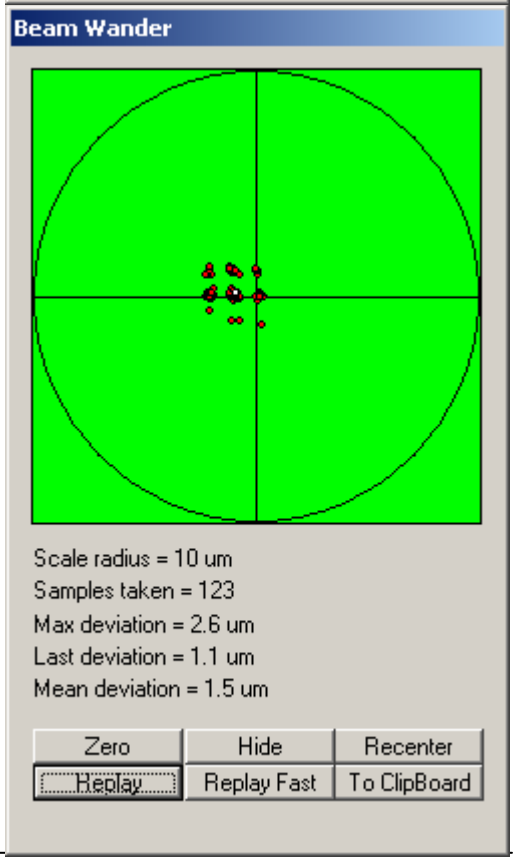
Zero restarts the plot.

Recenter recenters the plot.

Hide hides the box but continue the plot.

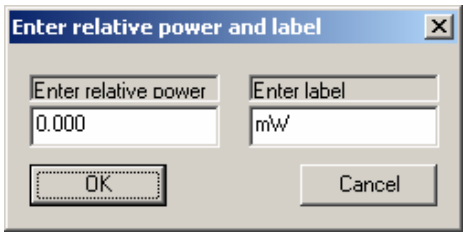
Replay or **Replay Fast** replays the beam position history.

To Clipboard puts the **Beam Wander** to the Windows Clipboard.



- **Power Bar**

The auto-scaling Power bar function gives an indication of *relative* power as a scrolling ten sample histogram. The power is calculated as the integral of the energy under the profile curve (or in the image WinCamD series only). **It is not a calibrated power meter.**

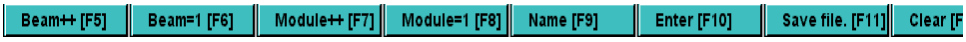


Click on the bar to open the dialog box shown. Enter the power as measured by a calibrated power meter, and the unit of measurement. The power bar will then display relative to the measurement entered.

If you enter **dB** or **dBm**, it will recognize these terms and work in logarithmic mode.

You may also enter **100** as the number and **%** as a label to give answers in %.

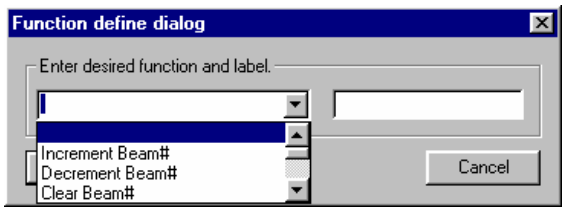
- **Show Function keys** does precisely that.



Function keys are user definable on-screen shortcuts. These on-screen keys parallel the F5 to F12 keys on your keyboard.

Left click on a key to bring up the **Function define dialog** box shown here.

Scroll through the options. They allow you to view particular profiles, particular beams, and/or particular heads, manipulate files, etc. [The available selection may change as the software evolves.]



Select a function and a label. To change the allocation of a function key, hold down the shift key and click on the function key to be changed.

- **Show 2D**

  Update live 2D, slows update
  Show 3D
  Update live 3D, slows update

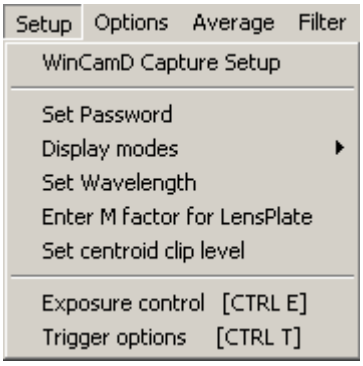
  These options allow you to choose what is being updated on-screen. Selecting **3D** functions may slow the screen update rate on slower PCs. If you select **Show 2D** but not **Update live 2D, slows update**, then the 2D graphic only updates when you stop data collection.

- **Fluence Dialog [CTRL F]**

  See Section 3.2.12, the **View** menu.

3.3 SETUP

- **WinCamD Capture Setup**

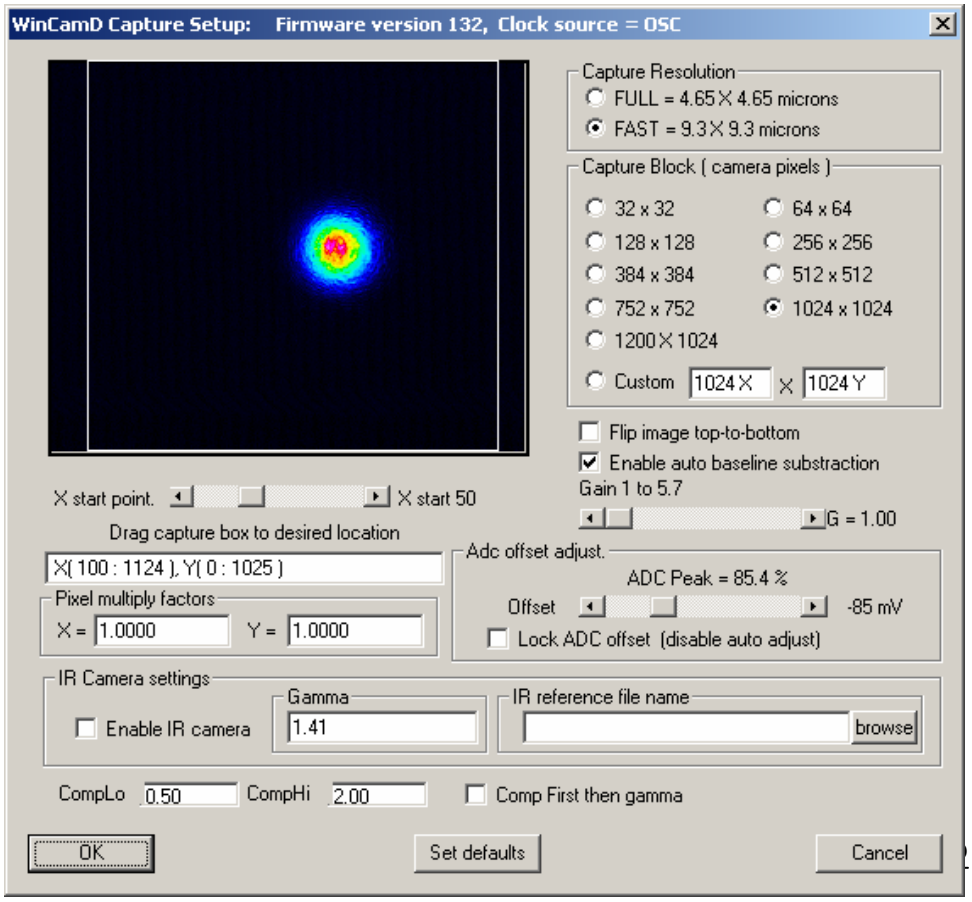


Press **Ctrl W** to open the **WinCamD Capture Setup** dialog.

The top of the dialog screen shows the **Firmware version** and the **Clock source**. If you see problems, Product Support may ask for this information.

This screen operates in live mode only and allows you to do the following, preferably in this order:

1) **Capture resolution**. At the expense of a factor of two in linear resolution, you may approximately double the speed of image capture by choosing **FAST** rather than **FULL**.



2) **Capture Block**. Select the image size that you wish to capture. Drag-and-click it on the small screen in the dialog box in order to place it over the beam area of interest.

   Using a smaller **Capture Block** increases the frame rate in nearly *inverse* proportion to the number of vertical lines. I.e., fewer lines, faster capture rate.

3) **Flip image** flips the vertical orientation of the image. Its default is unchecked, to ensure that positive Y is up.

4) **Gain**. **G = X.X** With **CW** lasers, this is only used if the beam is so faint that even at the maximum 1024 ms exposure with the ND filter removed, the **Peak** is still not reaching >80 %. On some early cameras it is necessary to set the gain high to avoid profile saturation at a level below100%.

   With **Pulsed lasers**, where exposure control is ineffective for pulse widths less than several tens of ms, and the user must insert sampling &/or attenuation in a quantized manner, **Gain** allows the user to set the Peak to a suitable value.

5) **Offset**. The offset is set automatically at 2 −0.2 % of the ADC full-scale range. This ensures that the noise although very low, is properly sampled. [Though optical intensity is by definition always ‡0, voltage noise will have negative components.] You may choose to disable this function by clicking the **Lock ADC offset [disable auto adjust]** box, and then setting the **Offset** to the value you choose by setting the **Offset** slider. The **Offset** is shown in **mV** and as **ADC Peak = X.X %**.

6) **Drag capture box to desired location**. The slider bar allows you to access the full 1360 pixel CCD width. The box below shows the location of the top left hand edge of the box. This will be changed to the center of the box in a future software revision.

7) **Pixel multiply factor**. Allows you to adjust for ancillary optical elements that may change the scale between the object plane and the CCD pixel plane.

   E.g. Use 2.27 for TCamD, TCamD/IR or 3.1 for the TCamD20/15, TCamD20/15/IR.

8) **IR Camera Settings** now includes the ability to select the **Enable IR Camera** option with a default gamma value of $\gamma = 1.41$, plus the option to implement the uniformity correction file that ships with the camera.

   Check **Enable IR Camera** box to enable this option. If a compensation file was provided, format **WCDIRCompDxxxx.wcf**, where **Dxxx** is the serial number on the back of the camera, then **browse** for this file and select it.

   The **CompLo** and **CompHi** boxes allow you to set alternative defaults to the maximum and minimum correction factors to be used.

   [To reverse the normal correction order , check the **Comp first then gamma** box.]

The 'Gamma' (Greek 'γ') of a camera is the power relationship between the output video signal and the input irradiance (intensity):

$$\text{Video Signal} = (\text{Input irradiance})^{\gamma}$$

γ values below 1 'soften' the intensity differences in the scene, and are commonly found in consumer and surveillance cameras, rarely in industrial cameras, and frequently in 'vidicon' style IR cameras.

Gamma correction is *not* required for WCamD, TCamD cameras, which have γ= 1..

- **Set Password**. Entering the current Password allows you to reset the global password to a new Password. Password protected functions are locked when this option is selected. (See 3.2.4)

INCREDIBLY IMPORTANT!!!

You must record/remember the new Password that you set.

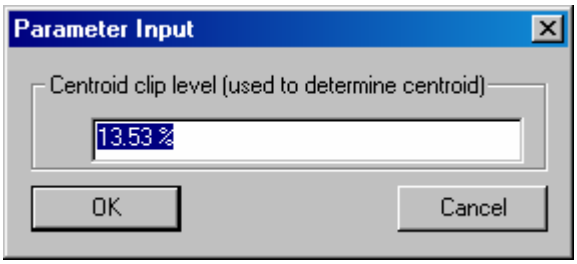
We cannot retrieve this for you.

- **Display Modes** is discussed in Section 3.2.3

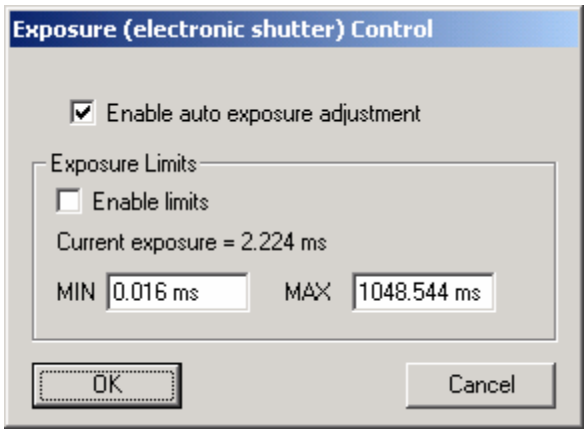
- **Set Wavelength**. Allows you to enter the wavelength of operation. Irrelevant at this point in time, but will be relevant once M^2 measurement with lenses is added.

- **Enter M factor for LensPlate** allows you to correct for use of the LensPlate accessory, normally only used with Beam'R and BeamMap units. Not normally used with WinCamD which has the **Pixel multiply factor** option.

- **Set centroid clip level**. Allows you set a default other than the 13.53% ($1/e^2$). The centroid is calculated for all pixels with % level above the centroid clip level. Currently, the level may be set between 5% and 90%. If you try to set higher or lower values, it will default to 13.53% without warning you.



- **Exposure control [CTRL E]** opens the dialog box. The box may also be accessed by right-clicking on the line below the 3D screen area.



- For CW lasers, you may **Enable auto exposure adjustment** by clicking the box. You may also **Enable limits** to set the range within which this function is allowed to operate.

- **Trigger options [CTRL T]** opens the dialog box described in Section 4. The box may also be accessed by right-clicking on the line above the 3D screen area.

3.3.1 Options

- **TEM[0,0] only**. Select this (default) option to force a simple $TEM_{0,0}$ Gaussian fit.

  If you keep this unchecked. In this case, if the software detects that the profile contains more than two crossings of the 13.5% level, the fit will be the appropriate $TEM_{X,0}$ fit (up to $TEM_{3,0}$ rather than a simple Gaussian $TEM_{0,0}$ fit. If it detects 'n' crossings of the 13.5% level, it will fit a $TEM_{(n-2),,0}$ curve to the profile.

- **Auto name files**

  If you select this option, when you save a file a name will be suggested in the format:

  BX_YY_MM_DD_HH_MM_SS

  … which is a device abbreviation (BM, BC or BR) followed by the date and time (24 hour clock) read off your computer's clock.

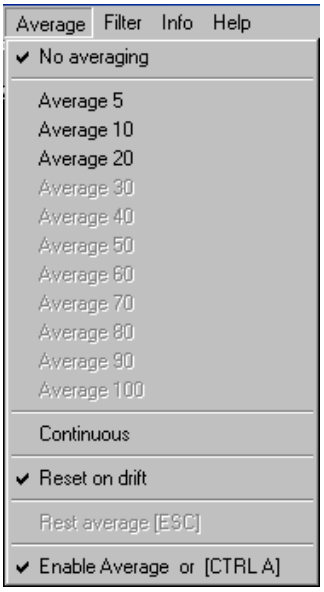
  [In the future this may change to a shorter version: BXYYMMDD_HHMMSS]

- **Fluence**

  From the **Options** menu, select **Show Fluence Dialog [CTRL F]** to open the fluence screen. See Section 3.2.12, **View** for a description.

3.3.2 Average

Opens the Image Averaging menu.



Choose either a running average based upon a specific number, **Average 5** to **20**, of profiles, or choose **Continuous** (accumulation) averaging of the profiles. An averaging mode indication will appear in blue on the profile graphic.

Reset on drift resets the averaging in the centroid position when the drift is (currently) >5 mm.

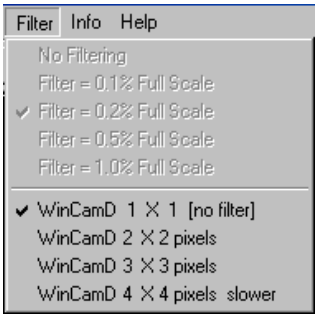
The displayed results are derived from the averaged profile.

Reset average [ESC]. Press or the **Esc** button on the keyboard to restart the averaging.

Enable Average or [CTRL A]. If this is checked (the default), **CTRL A** toggles averaging on and off.

3.3.3 Filter

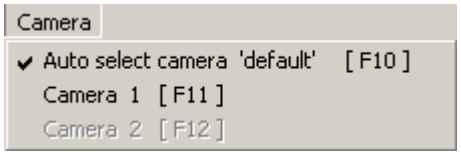
Filter selects an area smoothing function performed as a running smooth of the image. The default is no filter.



The area image filter, for WinCamD series only, calculates the average of the sum of the pixels over the specified sample. E.g. on **3 x 3 pixels**, it takes all nearest neighbor intensities, sums them, divides by 9, and places the result at the center pixel location.

3.3.4 Camera

Camera selects the camera to be used.



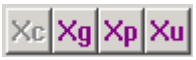
3.3.5 Help

Contains no useful information at the time of writing. Will be added in later releases.

3.4 BUTTON BAR BUTTONS

Some Button Bar buttons have already been addressed; this section summarizes the functions.

Clear, Open, Save. These three buttons, in order, Clear the data from the screen, and Open and Save files.



Select the centroid mode to determines the position of the intersection of the crosshairs.

Xc - the mathematical centroid for all points above the level set in Section 3.3.

Xg - the geometrical centroid for all points above the set centroid level. [Geometric centroid is the center of all the beam above the **Clip[a]** level, with no intensity weighting.]

Xp - sets the crosshairs on the peak in the profile.

Xu - allows the user to place the crosshairs

Normal and ***F***ast Mode. **N** & ***F*** allow display in **N**ormal or ***F***ast display mode. When the **N** button is grayed out you are operating in normal mode, and standard and user requested calculations are performed for the beam. This may limit the speed of the screen update. Select ***F*** to tell the software to simply update the screen as fast as possible.

Lock Baseline. The padlock style **Lock** and **Unlock** buttons allow you to Lock the baseline. This allows the measurement of beams which overfill the screen and are therefore too large to allow the determination of a good zero level while the beam is on the camera.

To use this feature, block the beam and click on the **L**ock button. Then allow the (CW or pulsed) beam to illuminate the screen. The zero level from which clip levels are determined will be based on the level determined while the beam was blocked.

Obviously (?), because the beam wings and true zero level are not imaged, second moment (4σ) widths calculated for such a beam are invalid.

To disable this feature, click on the **U**nlock button.

X, **Y**, **B** & **L** allow display of the **X** profile only, the **Y** profile only, **B**oth X & Y proflies, or **L**arge in which the profiles are not shown.

The **L**arge option allows the viewing of a screen from across the lab.

Select **B** to return to the default screen.

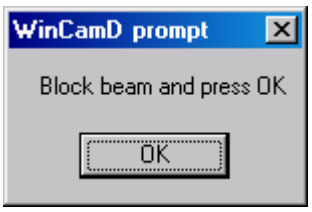
Go, Single Shot and Stop.

The **G** button starts the capture of images by the head, or press **F1**.

The **S** button stops the capture of images by the head, or press **F2**.

The **1** button initiates single shot capture of images by the head, or press **F3**.

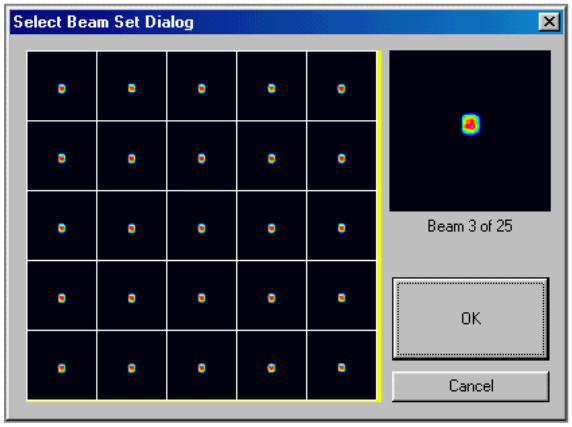
Background subtraction. Pressing the left hand **[-]** button to initiate background subtraction. The box shown right will appear. Block the beam and then click **OK**. The captured background will be subtracted from subsequent images.



Press the right hand **[ ]** icon to disengage this feature.

To auto-subtract the minimum level in the scene, press **Ctrl W** and check the **Enable auto baseline subtraction** box in the **WinCamD Capture Setup** dialog box.

Select Beam Set Dialog The matrix button opens a dialog that allows you to select an image beam from the stored set. Move the cursor over the array to view a beam.

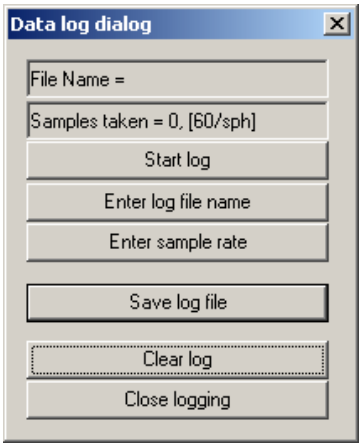


The left-right keyboard arrows allow you to scroll through the beams without first opening the dialog. The caption line at the top tells you which beam you are looking at. **Page Up**, **Page Down** has the same effect.

Live versus Saved. These buttons allow you to toggle between live mode and saved data.

Reset Averaging. This button clears and restarts the averaging.

Log Data Opens the Data log dialog box. Log data to the hard drive and to accumulate statistical results (averages and standard deviations) on the results. Save the results as a *.log file and recall the results as required.
Click on Enter sample rate to enter a rate between 1 and 3600 sph (samples per hour).



The rest of the buttons in the Data log dialog are self-explanatory. Logged data is saved as ***.log** text files which may be imported into programs such as Excel using **,** and **;** (comma and semi-colon) as delimiters.

In the future, this function will include the ability to directly plot selected data as Microsoft Excel graphs in real time. The plots will be of any of the data calculated by the software, with plotting versus booth sample number and time. This will bring the power of Microsoft Excel data plotting to all data, and the ability to save data as ***.xls** files. This software is in preparation, with release scheduled for summer 2002.

Print & Print with Notes. This pair of buttons allows you to print just the screen or the screen with additional notes. In either case the header includes the software version number, and the day and date of printing. The file name will be added to this default header in the near future.

3.5 SHORT CUTS

Keyboard Short Cut keys are tabulated below. Some require hardware to be present.

F1	Starts active image acquisition	**Page Up**	Access previous image
F2	Stops active image acquisition	**Page Down**	Access the next image
F3	Single frame capture	**Alt F4**	Exits the program
F10	Auto-select camera		
F11	Chooses Camera 1		
F12	Chooses Camera 2		
a	Selects absolute position display	**Ctrl Alt E**	EEPROM programming
b	Selects both profiles	**Ctrl Alt S**	Opens input box for the Sigma power inclusion percent
c	Centers the profile in the grid		
g	Go (Start); starts data collection	**Ctrl Alt W**	Opens WinCamD debug. *Factory use only*.
i	Zooms in		
o	Zooms out		
p	Pan the profile		
r	Resets Profile scale Zoom to 1X		
s	Stop; stops data collection		
x	Selects x profile		
y	Selects y profile		
Ctrl B	Opens Beam Wander		
Ctrl E	Opens Exposure Control dialog		
Ctrl F	Opens Fluence dialog		
Ctrl O	Opens a file		
Ctrl P	Prints the results		
Ctrl S	Opens Save dialog		
Ctrl T	Opens Trigger dialog		
Ctrl W	Opens WinCamD Capture Parameters dialog		

3.6 HARDWARE QUICK-START TUTORIAL

3.6.1 Precautions and Safety Warnings

Do not skip this. If you do not take these precautions, you may damage the equipment or your eyes.

- When installing PC cards always remove the power cord from the computer and count to twenty in order to let voltage lines go to zero. Failure to do so can damage you, the computer and/or the system.
- Be aware of electrical hazards. When installing PC cards, check to make sure that the boards are properly seated in their sockets. Keep the operational environment clean and dry. Use only low pressure, clean dry air for removing dust.
- Always measure the beam power and try to estimate the beam diameter before analyzing a laser beam for the first time. Ensure that it meets the maximum irradiance and maximum power limits in the specifications.

Follow the guidance in Chapter 5

- Be aware of the laser beam path and its reflections. Where appropriate use beam blocks and *Wear Proper Eye Protection* for the wavelength being analyzed.
- Always close the program properly. Never turn off the computer while the program is active. Failure to shut down first can result in the accumulation of fragmented files.
- Since image capture and manipulation is processor intensive, and though we have experienced no such problems on Ethernet linked PCs, conflicts *may* occasionally occur with networked computers. We can give no assistance in solving such problems; the normal solution is not to log on to the network when using the program.
- Image spots and diffraction rings. See Section 3.6.3

3.6.2 Starting Up

a) If you have not already done so install the PC Card and software - Sections 2.2 and 2.3. *With the software off*, connect the head to the PC card using the cable provided.

b) **Eye Safety**: If the beam power is high, put on your laser safety goggles before you turn on the laser. ***It is your responsibility to determine eye safety issues.*** Use a viewer or phosphor card for beams invisible to the naked eye.

c) ***Disconnect the cable before moving the camera head a large distance***. You ***may*** hot-plug and un-plug the camera head while the software is on. If you continually move the head around with the cable attached, drag on the cable may cause the spring clip connector retention shell to bend and weaken.

Mount the head in a rigid manner such that the head will intercept the laser beam in a plane perpendicular to the beam axis.

It often helps to install the head or the assembly to be measured on an XYZ stage.

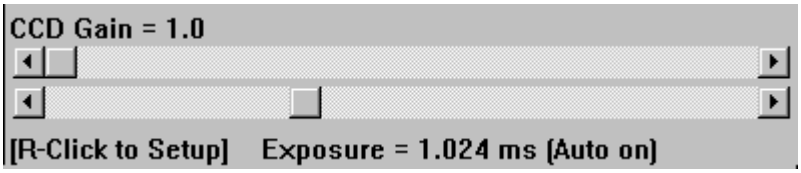
3.6

d) If you have not already done so, read this manual.

e) If it is the first time you are using the software, but have been experimenting with the settings, go **File**, **Load defaults**, to reset the software to its defaults.

To start taking data, press '**g**' on the keyboard or click on the **Go** or **Ready** button.

The defaults include auto-exposure. This ensures that the exposure will be set to 1.024 ms initially and then automatically adjust for your beam in the range 16 ms to 500 ms. If it needs a higher exposure, then disable auto-exposure by right-clicking on



the bar to access the dialog box. Set the **Peak =** to around 85 to 95%.

The defaults set the Inclusion Region image size to 1024 x 1024 and fast mode. Enter **Ctrl W** to enter the setup screen and change the values in accordance with Section 3.3.

Once the beam is set within the image area, the readings will be accurate and the profiles may be analyzed as discussed throughout the earlier in the chapter.

f) When you close the software, it will automatically save the settings that you were using when you exited. To save an alternative and consistent set of settings, use the ***.job** file approach outlined in section 3.2.8.

When you next open the software, you may carry on with the settings saved on the last exit, load the defaults, or load a saved ***.job** file.

g) If you are working with pulsed lasers, read and understand Chapter 4.

h) The standard cable supplied is a 3 meter (10 ft) cable. If you need a longer or shorter cable, then you may purchase one at your local electronic store. It is a standard 6-pin

IEEE 1394 cable; beware - there are 4-pin 1394 cables – these will not work. Standard alternative lengths are 2 and 4.5 meters (6ft 8 in. and 15 ft.)

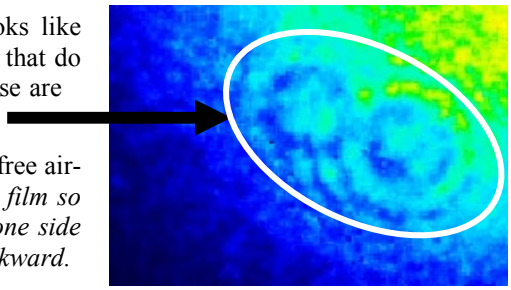
i) **Background image subtraction** … see Section 3.4

j) **Large images** … if the beam is larger than the image area, you may still measure it at a clip level that lies within the image area, even though the edges are outside. Set up the beam to a reasonable **Peak =** level and then disable the auto-exposure. Then block the beam, press **Ctrl W**, and **Lock ADC offset**. Click **OK**, unblock the beam and then measure it in the normal way.

3.6.3 Artifacts and Cleaning of the ND filter & CCD chip.

The first advice is "Do not", but sometimes it becomes necessary.

Dust on ND filter. If you see what looks like circular diffraction patterns on the screen that do not move with the source image, then these are dust specs on the ND filter.



These are most easily cleaned with an oil free air-duster. *Some air duster fluid can leave a film so keep the can upright, do a test spray to one side first and bend the nozzle if the angle is awkward.*

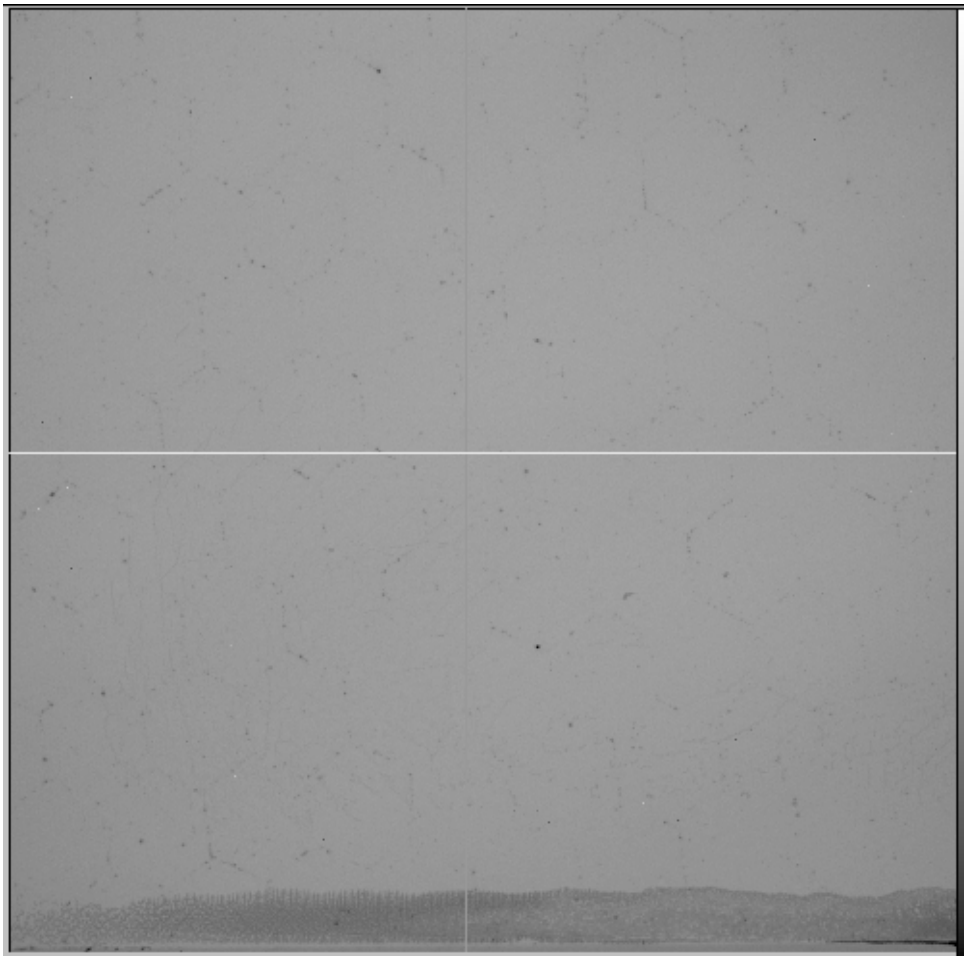
If the problem is finger marks, rub with a small quantity of laboratory grade ethanol or methanol on a lint-free cloth (paper towels are quite good, paper handkerchiefs are appalling). Sometimes you have to do an alcohol wash with a cotton bud first, followed by an edge to edge blow-dry.

Some marks can be water-soluble but not alcohol-soluble. Rub with a damp lint-free cloth.

Dust on CCD chip. If you see very small black spots on the image that do not move with the source image, then this is dust on the chip. Some level of dust is inevitable, so try to avoid the pursuit of perfection. However, if the dust is interfering with the measurements, **at your own risk**, remove the ND filter, put the camera under a low power microscope and use an oil-free air jet to blow the surface of the chip. *Some air duster fluid can leave a film so keep the can upright, do a test spray to one side first and bend the nozzle if the angle is awkward.* Damaged chips can be replaced *but at your expense.* (~$450 for standard chips, higher for /IR chips.).

- **Do not touch the surface of the chip.**
- **Do not blow directly on the fragile bond wires**

3.6.4 TaperCamD Artifacts



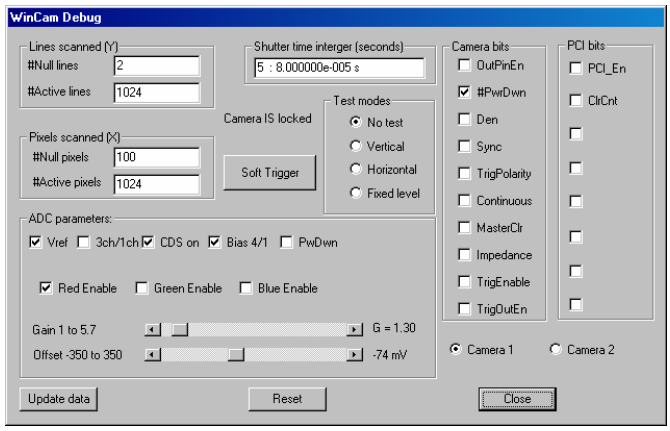
- **Chicken Wire**. Due to the bundles of the fibers used in the fiber optic taper manufacture, TaperCamDs will show a slight hexagonal 'chicken wire' pattern of pixels of varying degrees of insensitivity, with a pitch of ~100 pixels on the 2.27:1 taper and ~TBA pixels on the 3.1: 1 taper.
- **Edge misalignment**. Early assembly techniques led to a soft edge of up to ~5 % of the image area, where the taper edge is misaligned with the identically sized CCD edge. This assembly tolerance was improved to better than ~2% on later versions.

Both these are inevitable consequences of the use of fiber optic tapers. If you the customer find these artifacts to be unacceptable in your application, you may return the unit for a full refund, *but not replacement*, within 30 days of receipt.

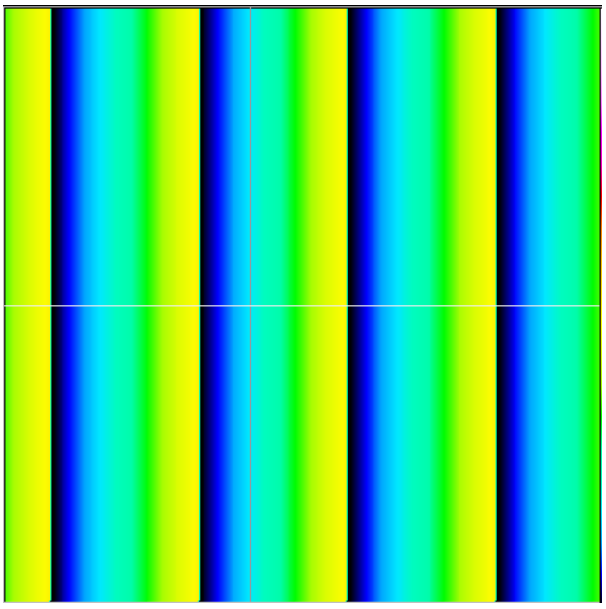
3.6.5 WinCamD Debug Screen

Normally ignore this screen, accessed with **Ctrl Alt W** . Technical Support may need to refer you to it.

You may prove that the camera is connected to the card by selecting **Vertical** under **Test modes**, then **Update data** and **Close**. Then press **g** on the keyboard. If the camera is connected to the PCI card, you will see the screen shown below.



If this screen does not appear (1024 x 1024 image shown), either the camera head or the PCI card, or the cable has a problem, or you forgot to connect the cable at each end (trust us ... it happens).



CHAPTER FOUR

4 CAPTURING PULSED LASERS

WinCamD makes pulsed beam capture as simple as possible. That said, ***learn to operate the software with a simple CW beam before you try to operate with a pulsed beam***. Trust us on this … your time will be well spent.

WinCamD:

- Has comprehensive Auto Trigger capability
- Can synchronize to a +3.3 to +5V amplitude (preferably TTL) input pulse.
- Can output a 2 V LVTTL sync pulse to trigger a laser.
- Can advance/delay the electronic shutter with respect to the input/output trigger.
- Can 'dissect' pulsewidths >16 ms, and with synchronous triggering. The pulse may be 'dissected' by using an exposure time less than the pulse width and temporally scanning it across the pulsewidth.
- Can vary the shutter exposure time from 16 ms to 1.05 s, allowing beam 'attenuation' on pulsed beams with pulsewidths greater than 16 ms.
- Allows you to vary the CCD gain by a factor up to 4.4:1 (6.5 dB). [Use of CCD gains >1 lead to lower SNR (Signal-to-Noise Ratio).]

4.1 TERMS AND FEATURES

A **Synchronous Camera Trigger** occurs when the camera is triggered by a sync pulse from the laser. This is the optimum approach, but cannot always be achieved.

A **Synchronous Laser Trigger** occurs when the laser is triggered by a TTL sync pulse from the camera head. This is fairly rare in practice.

CCD Exposure/Electronic Shutter. The light falling on the array leads to a proportional integrated charge *while the electronic shutter is open*.

Be aware that the terms **Trigger**, **Gating** and **Capture** can sometimes be used interchangeably, and sometimes imply different things.

Trigger strictly implies that something happens *as a result of* some input.

Gating implies that the presence of something allows something else to happen.

Capture is the act of capturing a pulse.

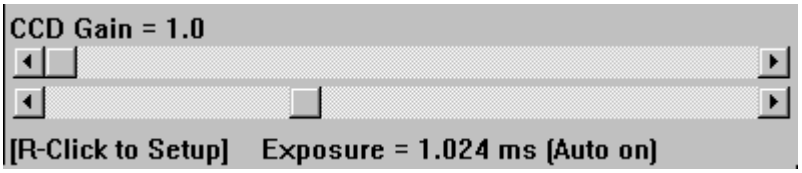
PRR is the **P**ulse **R**epetition **R**ate of the laser.

SNR is **S**ignal to (rms) **N**oise **R**atio

Progressive scan. WinCamD uses the technique of 'Progressive Scan' where the CCD is read out as a continuous line sequence over the range of interest. In addition, it is no longer necessary to read out all the CCD from top to bottom before starting a new frame integration. The frame rate is field size and resolution dependent.

[Because of historical issues with vidicon tube and video monitor update rates and with eye-brain temporal response time, conventional CCD cameras used to be, and still may be, designed to work in frame mode with two interlaced fields per frame. This is totally unnecessary for beam imaging and degrades pulsed beam capture.]

- The electronic shutter opens once per frame. The *Exposure time* (integration time) can be changed in 16 ms steps from **0.016** to **1048.544 ms**, i.e. 16 ms to 1.05 s.
- The CCD uses the "energy in a bucket" integration method such that all energy [pulse(s) plus background] within the electronic shutter period is integrated. An ideal situation is that one laser pulse falls within the period when the shutter is open, and that the background is zero. It is therefore important to use a logical procedure to systematically change settings to correctly capture beams.
- Think of the 'comb' of laser pulses in a pulse train. A pulse will only be captured when it falls within an open shutter period. The pulse train and the CCD exposure period must coincide.
- The frame transfer timing pulse transfers all charges accumulated on the pixels, essentially clearing the whole area. For pulse durations >16 ms, the electronic shutter may be used to attenuate the background and the beam intensity.
- For pulse duration <16 ms, the electronic shutter can only gate pulse capture.
- The CCD gain may be increased to increased at the expense of increased noise.



4.2 PULSED BEAM CAPTURE INITIAL SETUP

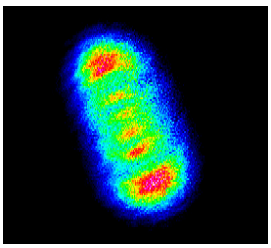
Capturing pulsed beams may require some experimenting to obtain the best results. WinCamD covers most conceivable triggering options, pulse durations and pulse repetition rates.

If you ignore the advice that follows, you may damage the camera head and/or your eyes.

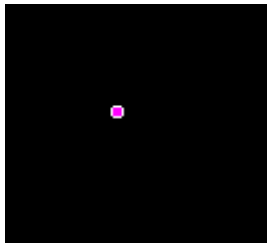
a) *Read and apply Section 3.6 and Chapter 5 for your personal safety and to set the power falling on the camera head to acceptable levels*. If you are unsure, move the beam in slowly from the edge to first pick-up the edge of the beam.

b) Normally, start in CW mode with the camera shutter maximized at 1.05 s, watching and centering the flashing pulses on the screen. [At this stage you are concerned with centering the beam on the CCD, not the saturation or otherwise of the signal.]

c) Note that the CCD Gain may be changed from 1 to 4.4 using the on-screen slider located just below the 3D display areas. Higher gains assist in setting the signal level (**Peak = xx.x %**) to its optimum value of ~90% (% of ADC saturation) but at the expense of somewhat degraded SNR.



GOOD



NOT GOOD

d) Next, minimize the 'dead' space around the beam by redefining the Capture Region (Section 3.6.3) to be as small as possible while still fully capturing the beam. *If this is not done, residual un-subtracted integrated image background may be a significant percentage of the pulsed signal, and may compromise correct capture and analysis.* [The software automatically subtracts overall background, based upon the lowest signal level in the capture region.]

e) Right-click on the 2D display area to select **Crosshairs snap to centroid. (default)** to ensure that the centroid of the beam is tracked. (Many pulsed beams wander).

Capturing pulsed beams may require some experimenting to obtain the best results. WinCamD covers most conceivable triggering options, pulse durations and pulse repetition rates. There are two modes of operation.

- Auto-trigger, where no laser synchronization occurs.
- Synchronized mode, recommended if the laser provides either a trigger output or a trigger input.

The sections which follow explain these modes.

4.3 AUTO-TRIGGER MODE

In Auto-Trigger mode, WinCamD will *automatically* capture and display pulses that lie within the intensity limits set by the user.

Auto-Trigger is attractive to many users of a WinCamD. It works well in many circumstances, but does have certain limitations. Auto Triggering *may* require some trial and error experimentation to get consistent results. It *may* require a level of knowledge of what is "good data", based upon a level of experience with the WinCamD and the laser being tested. However, if your laser driver provides a TTL trigger output or accepts an LVTTL trigger input, consider going directly to go to Section 4.4.

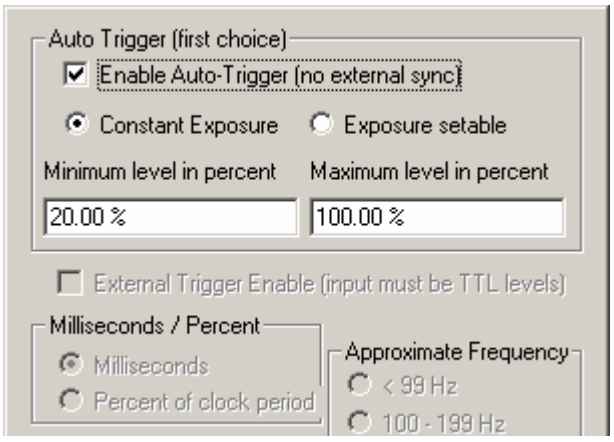
a) *Auot-trigger is totally ungated and untriggered*, with a simple upper and lower intensity level criteria to Accept or Reject images each time a frame is captured.

b) Capture status messages are displayed in the box on the left hand side immediately below the button bar.

Auto-Trigger Mode Operation.

a) As previously advised, first set up approximately in CW mode.

b) Press **Ctrl T**, or right-click on the non-slider area of the **Trigger Control** box, to open the dialog box shown, and select **Enable Auto-Trigger (no external sync)**.



c) Unless you have a reason to select otherwise, start with the defaults of **20%** and **100%** for the **Minimum** & **Maximum level in percent** respectively. The **%** is expressed as a proportion of the saturation level of the ADC. Beams with intensity above 100% will also be captured. Setting to any value below 100% (e.g. 99%) excludes such beams.

d) **P**ulse **R**epetition **R**ate dependencies.

PRR < 1 Hz. Choose **Exposure settable** mode and set the exposure appropriately. Every pulse can be captured.

1 Hz < PRR >~1 kHz. Choose **Constant Exposure** or **Exposure settable** mode. One or more pulses may be captured, depending on the **Exposure time**. The **Exposure time** will typically be several tens or hundreds of ms, and always lies between 16 ms and 1 s.

PRR >~1 kHz. Choose **Exposure settable** mode. One or more pulses may be captured, depending on the **Exposure time**. The **Exposure time** will typically be several tens or hundreds of ms, and always lies between 16 ms and 1 s.

PRR > 60 kHz. Multiple pulses will always be captured.

e) **Constant Exposure** mode. The camera will repeatedly capture images as fast as the software, the PC and the **Capture Block** setting will allow. In this setting the shutter is open continuously, except during the brief period when the image is being moved to the interline transfer register.

Pulses with an ADC % within the set levels will be captured and displayed.

The **Exposure time** depends upon the number of lines in the chosen image size and whether **Full** or **Fast** mode has been selected in **WinCam Setup**. For the fastest update rate choose **Fast** and a **Capture Block** area which is just sufficient to fully capture the pulse.

Neither Auto-exposure nor Manual exposure changes the exposure time. The software will totally ignore these settings. In a future software release, the actual exposure being used in this mode will be shown in the **Shutter Control** box.

f) **Exposure settable** mode. Only choose this mode if you wish to use the **Exposure time** to help control the beam saturation.

'Control' can mean attenuating a single wide pulse beam by capturing only a part of that beam (e.g. a pulsed LED) or sampling a string of high PRR laser pulses by capturing a larger or smaller number of pulses during each exposure.

Normally, the **Exposure** should be set slightly below the inverse of the PRR, in an attempt to capture only single pulses.

E.g. If the PRR is 200 Hz, set the exposure time to just below 5 ms (1/200) in order to capture nearly every pulse. If background illumination levels are a problem, set the exposure time to a lower value, but at the expense of probability of pulse capture.

The *maximum* Capture rate will be the same as in **Constant exposure** mode, but the **Exposure time** may be set greater or less. If it is greater, then the capture rate will be slower.

The camera will repeatedly capture beam images, as fast as the set **Exposure** (set below the 3D display area), the software & the PC will allow. Images with intensities within the **%** criteria set will be captured and displayed.

g) **Intensity Variations.** Because the Auto-Trigger mode is asynchronous with the pulsing laser, the intensity will fluctuate to a greater or lesser extent as one or more pulses fully or partially overlaps the exposure period, and one or more pulses gets included.

To restrict the captured images to unsaturated images of reasonable intensity, set the **Maximum level in percent** to 90%, and increase the **Minimum level in percent**. Then adjust the external attenuators and/or the CCD gain until pulses are being captured. A narrow ratio between the **Maximum** and **Minimum** levels ensures that only single pulses will be captured.

Important:

If … you use an **Exposure** below the laser pulsewidth;
And … the pulse spatial distribution changes during the pulse;
Then … a single pulse image will not fully represent the pulse.
Instead … use External Trigger mode, below.

h) **Capture but too low!** If this message appears in the **Ready** area, it is telling you that a frame was taken, but the peak level was below the set **Minimum level in percent**.

4.4 EXTERNAL TRIGGER MODE

In this mode, WinCamD capture and display pulses by laser synchronization.

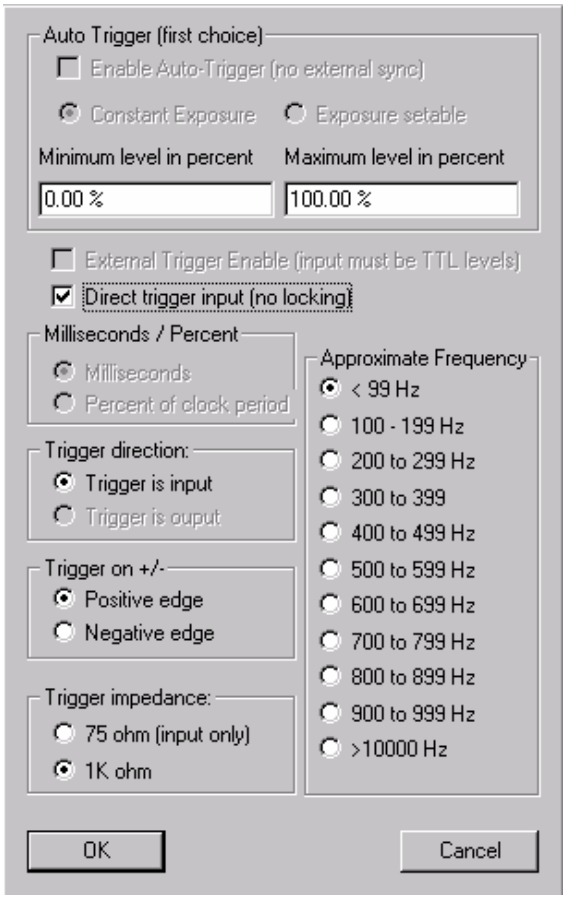
Caution should be exercised once a triggerable laser is connected to the WinCamD. The laser could trigger from the shutter signal immediately the camera is turned on.

a) **Ctrl T** opens the dialog box. Select either **External Trigger Enable (input must be TTL levels)** or **Direct Trigger Input (no locking)**.

b) **Isolated Pulse Triggering**. For some users (e.g. doing fusion experiments) single pulse triggering on the first incident pulse is required.

In such cases, use **Direct Trigger Input (no locking)** The camera will trigger on the single TTL input pulse and will also indicate on-screen how many pulses have been received. Set **Trigger is input**.

[**Important**: The WinCamD PCI card firmware ***must*** have been upgraded to the Version 5, true of all cards since March 1 '02. Unsure? See the **Firmware Upgrades to DataRay PC cards** App. Note at the website for how to check this.]



c) **Pulse Train Triggering**. Set up the dialog box in accordance with the trigger characteristics and the approximate laser PRR.

d) The BNC on the WinCamD head can be configured as an *input* or *output* socket. The expected input pulse is a TTL pulse.

Note that the **Trigger is output** option puts out a 2 V LVTTL pulse from a 1 kW source, not a 5V 'classic' TTL pulse. [A 5V TTL output is available to special request. Contact DataRay]

Attach a 50W or 75 W BNC cable to the BNC connector on the camera head. In most scenarios, the laser will provide the trigger to the camera. The BNC I/O impedance may be set at **75** W or **1 k**W. for output, normally set it to **1 k**W. To accept a trigger, set it to **75** W.

If it dos not work, verify the electrical pulse shape on an oscilloscope.

e) Initially set the **Exposure** time to a value equal to just under the reciprocal of the PRR (Pulse Repetition Rate). E.g. For PRR = 500 Hz, set **Exposure** = 2 ms.

4.4

f) Advance or delay the **Trigger Control** slider to change the timing of the capture in relation to the trigger pulse, until the whole pulse is captured.

g) Reduce the exposure time to minimize background, but not to the extent that the **Peak =** value is decreased. You may have to iterate d) & e) to ensure that as you reduce the exposure time it is centered around the pulse, rather than looking only at the front or the back of the pulse.

h) **Individual pulse dissection**. To 'dissect' an individual pulse, set an **exposure** time that is less than the laser pulse width and use the advance/delay feature to look at various temporal parts of the pulse.

Electronic Exposure Setting Table for Single Pulse Capture *from a Pulse Train*. These recommendations are for synchronous capture of a single pulse from a pulse train with a pulse repetition rate **PRR** per second and a pulsewidth **w** seconds. Press the **1** button in the Button bar to capture a single pulse.

Pulse Repetition Rate (PRR)	w > 1.0 s	1.0 s > w >16 ms	w <16 ms
PRR <1 Hz	Treat as CW*	**Initially set exposure to 1/PRR s.** Reduce exposure to: Attenuate background Attenuate the pulse	**Set exposure to 16 ms**
1 Hz< PRR <60 kHz		**Initially set exposure to 1/PRR s.** Reduce exposure to: Attenuate background Attenuate the pulse	**Set exposure to 16 ms**
PRR ≠60 kHz			**Set exposure to 16 ms**. Multiple pulses may be captured.

* WinCamD can also be used to completely capture single pulses longer than the CCD maximum exposure time of 1.05 s. For such long duration pulses, use image averaging (**5**, **10**, **20** or **Continuous**) and an appropriate exposure time to accumulate a period just longer than the pulse. E.g. for a 7 second pulse use **10** and an exposure time of 800 ms.

CHAPTER FIVE

5 LASER ATTENUATION

It is very important to understand this section

Cameras are designed to be sensitive to low light levels.

Lasers are high intensity sources.

If the laser beam ***Irradiance*** (W/cm^2 or J/cm^2) *exceeds the* ***Damage Threshold*** *(*Minimum signal/unit area which causes damage) *of the camera, irreparable damage may result.*

If the laser beam ***Irradiance*** (W/cm^2 or J/cm^2) *exceeds the* ***Saturation Irradiance*** *(*Saturation signal/unit area) *of the camera, a saturated image results.*

If the beam diameter overfills the camera active area, inaccurate measurement of the beam will result.

Typical attenuation factors required between laser beam and camera are factors of 10^5 to 10^{10} or more [ND5.0 to >ND10.0].

WinCamD cameras feature as standard:

- An ND4.0 optical attenuating filter (LDFP Low Distortion FacePlate) set at 3^o to the optical axis in order to avoid interference fringes.
- An additional electronic ND4.8 (48 dB or 60,000:1) capability for CW beams
- An additional electronic ND0.65 (6.5 dB or 4.4:1) capability for Pulsed beams

This makes achievement of the required levels of beam attenuation as simple as possible, but it is still important to understand what the considerations are, and how to address beam attenuation and large diameter beam measurement.

This chapter addresses appropriate attenuation/beam sampling techniques and the measurement of large diameter beams. 'Catalog Optics' companies can supply suitable instruments, optics and optical mounting hardware to meet most measurement, attenuation, and beam sampling requirements outlined here.

The notes in this chapter are provided for guidance only. DataRay Inc. and its Distributors and Reps accepts no liability for errors or omissions in these notes.

Where a recommendation not covered by this chapter is required, please fax or email a description of your problem, together with a diagram and full laser beam details.

5.1 IMPORTANT TERMS

- **Irradiance** (Power Density). For a Gaussian beam of $1/e^2$ [13.5% of peak intensity] width of '**2w**' cm, and total beam power '**P**' Watts, the peak **Irradiance** in **W/cm^2** in the beam, '**I_0**' may be calculated as:

$$I_0 = (2 \times P) / (\pi \times w^2) = 2.55.P/(2w)^2$$

- **Signal-to-Noise Ratio** [abbreviated as **SNR**] **SNR = Peak Signal/RMS noise**.

- **Pulse Repetition Rate** Pulses per second for a pulsed laser, abbreviated as **prr**.

- **ND** or **Neutral Density** is a commonly used logarithmic approach to defining the Attenuation Factor provided by a neutral (approximately wavelength independent) filter. It has the advantage that logarithmic numbers may be added and subtracted, whereas attenuation factors must be multiplied and divided. **ND** is defined as:

$$ND = \log_{10}(\text{Attenuation Factor})$$

E.g.	Attenuation Factor	ND Value	
	1	0.0	
	2	0.3	
	5	0.7	
	10	1.0	
	50	1.7	
	100	2.0	
	1,000	3.0	
	10,000	5.0	e.g. ND 2.6 is a ratio of 400:1

- **Electronic shutter**. Most CCD cameras offer an 'electronic shutter' mode in which the integration time per frame may be set less than the frame interval, effectively acting as an attenuator for CW inputs. Normally the shortest shutter period is 1/10,000 s (100 ㎲).

Compared with the normal frame time of 1/25 s (CCIR) this is an effective attenuation factor of 400 (ND 2.6). [For most third party cameras, the shutter period is selected using TTL level inputs and/or miniature DIP switches on the camera or controller. In either case this is inconvenient, inflexible and allows only coarse adjustment.]

For WinCamD series cameras, the software interacts directly with the electronic shutter controls on the CCD chip, allowing on-screen shutter control in 16 ms steps from 16 ms to 1.05 s.

[N.B. Third party cameras *cannot* take advantage of the software control offered by the WinCamD software.]

Obviously, use of an electronic shutter:

- *Does not* change the **Damage Threshold** in W/cm^2 for either **CW** or **Pulsed** lasers.
- *Does* change the **Saturation Level** in W/cm^2 for **CW** lasers.
- *Does not* change the **Saturation Level** in J/cm^2 for **Pulsed** lasers, *unless* the pulsewidth is greater than the minimum electronic shutter period of 16 ms.

5.2 ATTENUATION OF YOUR BEAM

Step 1. Estimate Beam Diameter and Peak Irradiance

a) Using a suitable calibrated Power or Energy meter, measure the laser beam total power 'P' Watts or energy per pulse 'E' Joules, preferably at the point at which you wish to measure the beam profile.

b) By viewing the beam on a diffuse screen, or by using an IR Display Card or IR viewer for IR lasers, or by calculation, or by some other means, estimate the laser **Beam Diameter**. This dimension will be assumed to be the '$1/e^2$' diameter estimate, denoted as '2w'. If you are using a lens or a microscope objective to magnify or demagnify the beam onto the WinCamD, then the beam diameter will vary as magnification 'M', and the irradiance will vary as $1/M^2$.

c) Calculate the **Peak Irradiance** for your laser. Consider and understand the examples, paying attention to units, mW versus W, and mm versus cm. Then perform the irradiance calculation for *your* laser.

Example	*Type*	*Mean Power*	*Beamwidth mm* *[2w @ 1/e²]*	*Peak Irradiance* *I_0 W/cm²* *[= 2.55.P/(2w)²]*
1	CW HeNe 633 nm	15 mW	1.0 mm	3.8 W/cm²
2	CW Laser Diode 780 nm	100 mW	3.0 mm	28 W/cm²
3	Pulsed, tripled Nd:Yag 355 nm	1.2 W [40 mJ/pulse 30 kHz prr 100 ns pulsewidth]	1.0 mm	306 W/cm²
Your laser				

In Example 3, note that, *as is almost always the case*, the laser pulsewidth is very much less than the 1.05 s maximum exposure of the camera. The prr of the Example 3 laser is such that 30,000 pulses are integrated over the maximum 1.05 s exposure.

However, if the prr is *slower* than the camera frame rate, then the Peak Irradiance value I_0 calculated from 'average power' *must be multiplied by the ratio of the frame rate to the prr*.

Step 2. Determine the Level of Attenuation Required

*You may skip section a) for WCAM6 & WCAM8 cameras. For detailed **Saturation Limits** for these cameras, including the effects of the wavelength dependence of the ND4.0 'Neutral' Density filter, see Section 4.5.*

a) Look up the **Damage Threshold** and **Saturation Irradiance** levels for the camera. For the WCamD and common third party supplied cameras, *without additional attenuation* these levels (guidelines only) are:

Camera	*@ λ nm*	*Damage Threshold*		*Saturation Irradiance 25 ms Exposure*	
		mW/cm^2	mJ/cm^2	mW/cm^2	mJ/cm^2 *
WinCamD	355	Few	~0.3	~0.3	~0.01
	630	"	"	~0.15	~0.005
	800	"	"	~0.1	~0.004
	1060	"	"	~10	~0.4
WinCamDUV	190	<1	<0.1	~0.5	~0.02
EP 7290 near IR	1550	~1	~10	~10	~0.3
EP 5450 far IR	10.6μm	~1	~10	~400	~15

[* Assumes a *single* pulse per frame period – this is sometimes true, *and* that the pulsewidth is less than the exposure time - this is almost always true. For pulsed lasers, with pulse repetition rates much higher than the camera frame rate, calculate peak irradiance based on the average power and use the mW/cm^2 saturation values.]

N.B. ***Damage Threshold*** relates to ***peak*** W/cm^2 since this is what causes damage.

Saturation Irradiance levels refer to an integration time (frame period) of 25 ms (Saturation levels are more normally quoted by manufacturers in lux or in mJ/cm^2 and are referred to a particular wavelength or illumination source)

b) Calculate the **Additional Attenuation** required for your laser. Consider and understand the examples, paying attention to units, mW versus W. Then perform the calculation for *your* laser. Working from the previous examples, for WCamD cameras:

Example	*Type*	*Peak Irradiance I_0 W/cm^2*	*Saturation Level* mW/cm^2	*Attenuation Factor Required*	*WinCamD (25 ms exposure time assumed)*	*Extra Required ND*
1	CW HeNe 632.8 nm	3.8	0.15	25.10^6 ND7.4	Passive ND4.0 + Electronic ND3.4	None
2	CW Laser Diode 780 nm	38	0.1	380.10^6 ND8.6	Passive ND4.0 + Electronic ND3.4	Additional ND1.2
3	Pulsed, tripled Nd:Yag 355 nm	306	0.3	1000.10^6 ND9.0	Passive ND4.0	Additional ND5.0
Your laser					Passive ND4.0 + Electronic ND3.4 (CW)	TBA

c) Ambient Background Attenuation. Although the WinCamD software offers background subtraction, for best dynamic range and SNR, it is better to reduce the ambient background to black level on the camera. Measurements under *typical* lab conditions showed a requirement for a reduction of the ambient level of around 10,000. The ND4 filter provided with WinCamD cameras provide suitable levels of ambient attenuation.

Step 3. Determine Whether Your Beam is Too Large for the Camera

Note the actual active area dimension of cameras. [The 'nominal' size is a legacy issue from the time of vidicon tv tubes which had standard glass envelope outer diameters, but smaller useful photocathode dimensions. It is the original glass envelope dimensions to which camera sizes and camera lenses are still referred in the CCD industry.]

Nominal	Part #	Active Area H x V mm	Diagonal mm (inches)	Vertical line spacing (μm)
1/2" CCD	WinCamD	6.4 x 4.8	8.0 (0.32")	4.65
2/3" CCD	[Third party]	8.8 x 6.6	11.0 (0.43")	13.6
	TCamD	14.4 x 10.8	18.1 (0.71")	18.7 (effective)
	TCamD20/15	20 x 15	25.0 (0.98")	25.7 (effective)
Near IR	EP 7290	12.7 x 9.5	15.9 (0.62")	19.6
Near IR	SU 320	12.8 x 9.6	16.0 (0.63")	40
Far IR	EP 5450	13.6 x 10.2	17.0 (0.67")	21.5 (~40μm resolution)

For accurate beam dimension measurement and to allow for centering adjustment, the $1/e^2$ (2w) beamwidth should ideally not exceed half the vertical dimension of the camera's active area dimensions. For beams larger than this, some form of demagnification scheme is required in order to reduce the beam diameter. See Section 5.4.

Step 4. Choose Appropriate Beam Sampling/Attenuation

Choose between the beam sampling/attenuation approaches given below. Note that since wavefront aberration, diffraction and interference results from the inclusion of any optical component in a coherent beam. Schemes that introduce the minimum number of reflections, optical surfaces, optical media (and dust & fibers on surfaces!) are clearly preferred. The catalog optics companies list a range of suitable accessories.

Techniques for beam attenuation/sampling may fall into the following categories:

- ***Absorbing Neutral Density (ND) filters.***

Attenuation factors up to ND5.0 ($1/10^5$) are available with single absorbing ND filters.

As standard we offer stackable ND filters, each in a circular housing with male and female C-mount threads. Filters are tilted by a few degrees to avoid interference fringes. Standard values are ND 0.5, 1.0, 2.0, 3.0, 4.0. Each filter assembly adds an additional 6.25 mm (0.25") in depth in front of the CCD chip.

We also offer the **EAM-2** C-mount 4-wheel variable attenuator assembly, offering >90 dB of attenuation. The **EAM-2** may be used in connection with a microscope objective to magnify smaller beams onto the WinCamD camera.

Do not attempt to attenuate high powers or power densities (irradiance) with absorbing ND filters. The absorbed power can cause the filters to shatter, presenting danger of injury in addition to damage to the camera.

Be aware that all neutral density (and metallic neutral density) filters are not truly neutral. ND values are normally quoted at 546 or 633 nm. See the appropriate catalog section for details of the wavelength dependence.

Note that 3.5" diskette material is uniform and has ND~2.0 and is sometimes a quick fix, but beware the fire risk if used too near to the focus.

- ***Metallic Neutral Density filters***

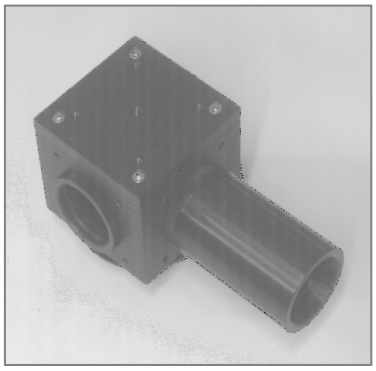
Attenuation factors up to ND4.0 (1/10,000) are available with single metallic ND filters.

Avoid reflecting the beam back into the laser. Care must also be taken to direct the reflected beam to a beam dump. Above ND2.0, metallic ND filters are highly wavelength dependent. For these reasons, metallic ND filters are normally not recommended.

- ***'Electronic shutter'.***

See the discussion earlier in Section 5.1. This is an excellent approach for CW beams, which is why the WinCamD series cameras exploit this feature with direct software addressing of the electronic shutter.

- ***Reflection off a window, prism or wedge front surface.***



Sampling factors from 4% for an uncoated window to <1% for an AR coated window. (ND1.4 to >ND2.0). An issue with *any* such reflection is the degree of polarization sensitivity as a function of angle of incidence. Catalog optics companies also offer suitable wedged windows. Note that fused silica damage thresholds can be as high as 1 kW/cm^2, so this can be a very effective way of dumping power.

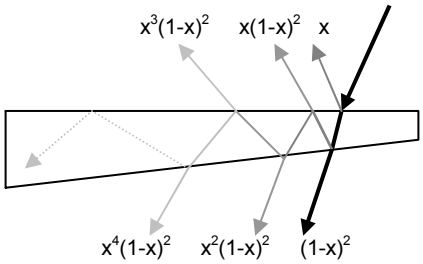
The **CUB** and **CUB-UV** are C-mount accessories which take a 3 to 10% sample.

- ***Multiple reflections in a wedge beamsplitter.***

Sampling factors of 1/1,000,000 are attainable, but multiple internal reflections *may* lead to interference if the beam divergence is comparable to the beam deviations in the wedge prism. Since the angular separation of the beams is 2$\jmath$, if the beam is large and $\jmath$ is small, it can be hard to determine which beam is being sampled.

If the reflection coefficient per surface is x, [around 0.04 (4%) for material with a refractive index 'n' of 1.5] then for angle of incidence θ, and wedge angle $\jmath$, then samples come off at the following intensities and angles:

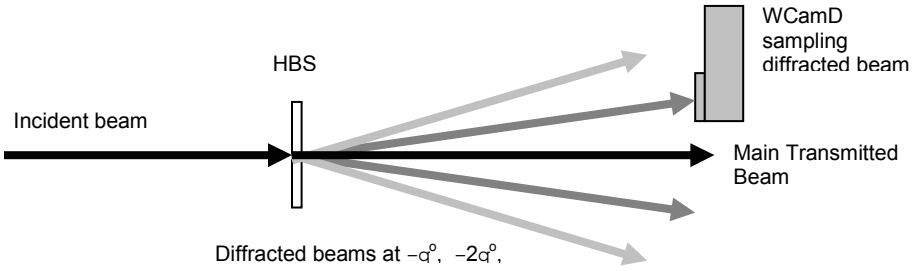
Surface	Intensity	@x=4%	Angle
Top	x	$4.0.10^{-2}$	- θ
Bottom	$(1-x)^2$	0.92	(θ+n$\jmath$)
Top	$x\,(1-x)^2$	$3.7.10^{-2}$	-(θ+2n$\jmath$)
Bottom	$x^2(1-x)^2$	$1.5.10^{-3}$	(θ+3n$\jmath$)
Top	$x^3(1-x)^2$	$5.9.10^{-5}$	-(θ+4n$\jmath$)
Bottom	$x^4(1-x)^2$	$2.4.10^{-6}$	(θ+5n$\jmath$)



Eventually the remaining energy is totally internally reflected. As angles approach the critical angle for total internal reflection, the sampled intensity becomes *extremely* sensitive to the polarization of the beam.

❑ *Holographic Beam Sampler (HBS).*

A holographic (diffractive) beam sampler transmits the main part of the beam and diffracts a percentage of the light into multiple orders off to one side. The hologram is a surface structure in the fused silica (used for silicon wavelength HBS's), giving substrate damage thresholds are as high as the 1kW/cm^2 of the starting material, just like wedges and windows. For pulsed beams, keep the level below 1J/cm^2, especially at <400 nm. A major advantage of HBS's over angled wedges and windows is their polarization insensitivity, <1% at 10^0 and ~5% at 20^0.



Sampling ratios range from 1/50 to 1/2,000 in first order. A 'typical' HBS is designed for a sampling fraction 's_0', at 'λ_0', at $-\alpha^o$ in first order. For two typical sampling fractions, the calculated sample intensities may be calculated as follows:

	α_0	s_0 = 1% (1/100)		s_0 = 0.05% (1/2,000)	
1st Order	-10^o	s_0 = 1/100	ND2.0	1/2,000	ND3.3
2nd Order	-20^o	$s_0^2/2!^2$ = 1/4.10^4	ND4.6	1/1.6.10^7	ND7.0
3rd Order*	-30^o	$s_0^3/3!^2$ = 1/3.6.10^7	ND7.6	1/2.88.10^{11}	ND11.5

*Due to manufacturing tolerances, the exact value of the sampling factor and angle in third order will vary and the beam may suffer some (unspecified) level of distortion.

At wavelengths λ other than the design wavelength, replace s_0 by s_1 and α_0 by α_1 .

Sampling fraction 's_1' @ $s_0.(\lambda_0/\lambda)^2$ i.e. s_1 *decreases* as λ increases.

Sampling angle 'α_1' @ $\arcsin[(\sin\alpha_0).(\lambda/\lambda_0)]$ i.e. α_1 *increases* as λ increases.

E.g. Consider a first order HBS designed for 1064 nm: $s_0 = 1\%$, $\alpha_0 = -10^o$

Used at 800nm the values change to: $s_1 = 2.1\%$, $\alpha_1 = -6.9^o$

Standard HBSs are wedged by (e.g.) 30 arcmin, perpendicular to the sampling angle plane, in order to avoid interference effects.

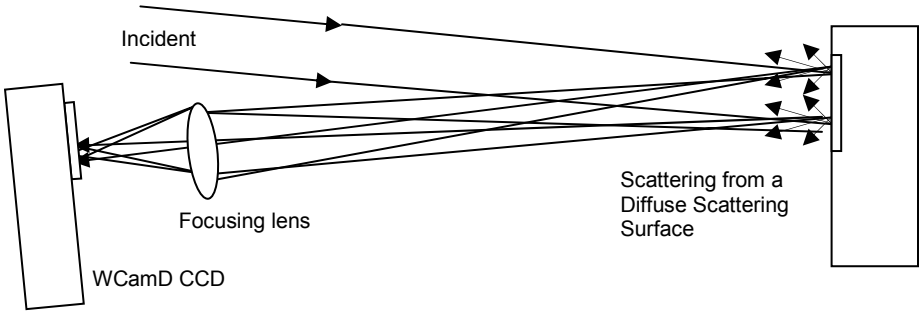
Sources of diffractive sampling optics include Gentec [www.gentec-eo.ca]. Note that binary gratings are not holographic gratings and though less expensive, may not perform as well in terms of ghost images etc.

5.3 UV LASERS.

Various manufacturers make conversion screens that convert UV to visible. Further information will be found in the future at the website. We sells StarTech UV beam imaging accessories.

5.4 WORKING WITH BEAMS LARGER THAN THE CAMERA

5.4.1 Imaging of the laser beam scattered off a diffusing surface.



This has been found to be a very effective technique. Not only is the beam image optically reduced to fit the CCD area, but also the scattering reduces the beam intensity.

- If a standard camera lens assembly with integral focusing and iris aperture is employed, then focusing is simple and the beam intensity can be further attenuated by closing the iris.
- If the incident and scattered angle employed are small and similar, the cosine distortion of the beam on the diffuser is compensated with the camera and lens aligned as shown, orthogonal to the axis of the scattered light.
- A perfect diffuser backscatters 31.8% per sr. (sr. = steradian of solid angle). For beams up to 24 mm *total* diameter, the Melles Griot SpeckleEater™ is a rotating diffuser that employs a rotating diffusing disk to eliminate speckle for CW beams.
- A 10mm lens aperture at 100mm distance samples $7.86.10^{-3}$ sr. and therefore would pick up ~0.25% (1/400) of the beam reflected off a perfect diffuser.

  More generally, if the beam image on the diffuser is focused through a lens iris aperture diameter 'D' at distance 'L' from the diffuser, (where D^L), then the effective **Collection Factor** may be calculated as **~0.25.(D/L)^2**. On top of this must be added the *increase* in irradiance of $1/m^2$ due to lens magnification 'm', (m is <1).

  Hence the total effective beam attenuation factor is: $1\ 0.25(D/mL)^2$

Since m l f/L the factor becomes: l 0.25(D/f)^2

l 0.25(1/Lens f-number)^2

5.4.2 Use of a long focal length mirror

Use a long focal length spherical concave mirror, worked slightly off-axis, to reduce the beam diameter to a size which will fit on the camera. Sample the beam along its converging path at a point where it is small enough for the CCD. This will inevitably result in some limited aberration of the laser beam due to both the off-axis operation of the spherical mirror and its residual surface imperfections.

5.4.3 Use of a long focal length lens

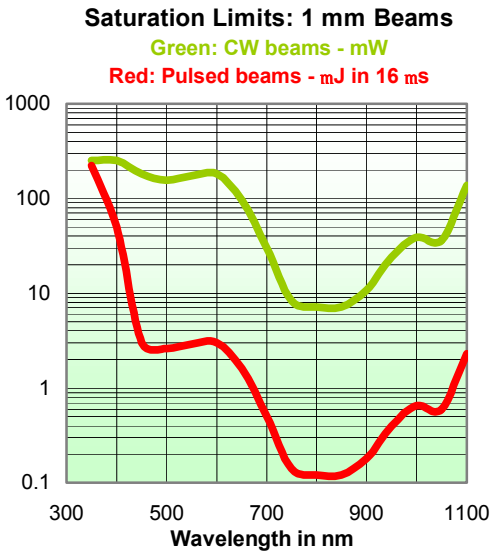
Use a high quality long focal length lens to reduce the beam dimension. As with the mirror, the introduction of any optic can change the characteristics of a coherent beam.

5.5 WINCAMD SATURATION POWER LIMITS

Maximum Power Graph

The graph allows you to simply determine the approximate maximum optical power that WinCamD can measure *without additional attenuation*. In both cases the **Saturation Limit** assumes:

- A $1/e^2$ (13.5% clip level) beam diameter of 1 mm
- The provided ND 4.0 filter in place
- The electronic shutter set at 16 ms, its lowest value
- The CCD amplifier gain set at 1, its lowest value
- ***The total power does not exceed 1W total***



CW Laser: The **upper** (green) line is the Limit for CW Lasers in **mW**.

E.g. At 633 nm the Saturation Limit for a '1 mm HeNe' is ~150 mW.

For a 0.1 mm diameter beam the limit is 10^2 **less** at ~1.5 mW

For a 3 mm diameter beam the limit *would* be 3^2 **greater** at ~1.35 W, but since this exceeds the 1W total, the limit would be 1W.

Pulsed Lasers: The **lower** (red) line is the Limit for Pulsed Lasers in **mJ of energy within 16 ms** (the minimum shutter period).

E.g. At 1064 nm the Saturation Limit for a '1 mm Nd:Yag' is ~1 mJ in 16 ms

If the Pulse Repetition Rate is £60 kHz this is 1 mJ per pulse.

If the Pulse Repetition Rate is >60 kHz this is <1 mJ per pulse.

For a 0.1 mm diameter beam the limit is 10^2 **less** at ~0.01 mJ in 16 ms.

For a 3 mm beam the limit rises by 3^2 to 9 mJ per pulse … except that the 1 W limit means that the PRR must not exceed ~50 kHz.

APPENDIX A: FUNCTION REQUEST FORM

To US Fax #: (303) 494-1431 Attn: Technical Support

Please answer the questions on this form to request/suggest a software and/or hardware upgrade. Fax the completed form to us. We will normally give an initial response within five working days.

Your Name: _____ Organization: _____
Phone#: _____ Fax #: _____ Email: _____

1) What is the request/suggestion? What exactly would this do?

2) What equations and/or parameters does this function use?

3) How do you want the results displayed and/or printed?

4) Please briefly describe the beam that you are trying to measure:

Wavelength _____

Mean Power _____ Beam $1/e^2$ diameter _____mm

Other _____

APPENDIX B: BEAMWIDTH DEFINITION & MEASUREMENT

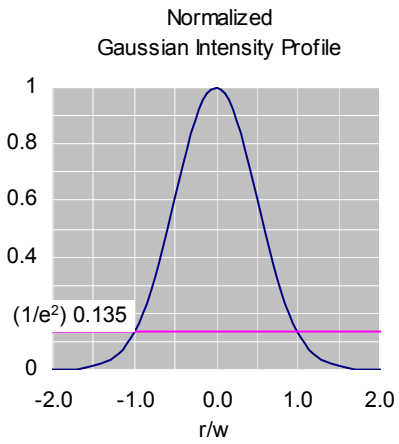
Beamwidth Definition

1. Gaussian Beams

True Gaussian beams have no 'edges'; that is, the intensity of a *perfect* Gaussian never actually falls to zero at large distances from the center. This arises from the nature of the (circularly symmetric) Gaussian intensity profile:

$$I(r) = I_0.e^{-2r^2/w^2} = \frac{2P}{\pi w^2}.e^{-2r^2/w^2} \quad \ldots.11)$$

Where: r is the radius
w is the *radius* at the point at which the intensity has fallen to 13.5% ($1/e^2$) of the peak value.
P is the total power in the beam



Replace r^2 by $(x^2 + y^2)$ and consider the profile at constant x and varying y. It is apparent that the shape of the profile is Gaussian wherever a cut is taken across the profile. It is this principle that allows slits and knife-edges to be employed in the measurement of beams that are close to Gaussian.

App. B 1

2. Beam Irradiance

In order to assess whether the irradiance (W/mm^2) from a given laser might overload a beam profiler, it is useful to be able to calculate the peak irradiance. From equation 11), the on-axis irradiance at r = 0 is given by:

$$I(0) = (2P/\pi w^2)$$
$$= 2.6P/(2w)^2 \ W/mm^2 \quad \text{for } \textit{diameter } 2w \text{ in mm.}$$

For example:

- The peak irradiance from a 1 mm diameter, 10 mW HeNe is 26 mW/mm^2.
- The peak irradiance from a 5 mm diameter, 5 W NdYag is 520mW/mm^2.

3. Second Moment Beam Diameter

Conventionally beam diameters have been measured at the $1/e^2$ intensity point; i.e. at 13.5% of the maximum intensity. For the reason outlined in section 2.2a), ISO 11146 mandates the use of a 'Second Moment' definition of beam diameter:

$$2W_s(z) = 2\sqrt{2}.s(z) \qquad \text{....12)}$$

where the variance, $s^2(z)$, is calculated as:

$$s^2(z) = \frac{r^2 I(r,f,z).r.dr.df}{I(r,f,z).r.dr.df} \qquad \text{....13)}$$

Where $I(r,f,z)$ is the radial intensity distribution versus angular position f, along propagation axis z.
In more useful x and y terms, (since these are what actually get measured):

$$s_x^2(z) = \frac{(x-\bar{x})^2 I(x,y,z).dx.dy}{I(x,y,z)..dx.dy}$$

$$s_y^2(z) = \frac{(y-\bar{y})^2 I(x,y,z).dx.dy}{I(x,y,z)..dx.dy}$$

$$2W_{sx}(z) = 4.s_x(z)$$
$$2W_{sy}(z) = 4.s_y(z) \qquad \text{....14)}$$

$\bar{x},\bar{y}$ denotes the centroid of the I(x,y,z) intensity distribution

(The ISO 11146 standard actually terms the quantities $E(x,y,z)$ rather than $I(x,y,z)$, and $d_{sx}(z)$ & $d_{sy}(z)$ rather than $2W_{sx}(z)$ & $2W_{sy}(z)$. Here we have used the more familiar terminology rather than the less common terminology used in the ISO standard.)

For a pure Gaussian intensity distribution, the second moment width is identical to the more familiar $1/e^2$ (13.5% of peak intensity) width.

There are a number of potential disadvantages to the use of second moment as a beam diameter definition, none of which are insurmountable in a well-designed system.

a) Unless the results are gathered and processed automatically, the second moment diameter is non-trivial to calculate. It is not possible to simply 'measure' it directly from a graphical plot of the data.

b) Any unsubtracted background in the wings, either purely analog noise or quantization noise due to inadequate dynamic range in the sensor or the ADC (analog to digital converter) leads to errors in the second moment. In general it leads to an over-estimation of the second moment width.

c) If the $I(x,y,z)$ intensity profile has wings which fall at a rate slower than $1/x^2$ or $1/y^2$, then the double integral actually *increases* as x and y increase.

For reasons b) and c) most commercial second moment beam diameter software first automatically determines and subtracts the background, and then truncates $I(x,y,z)$ to the zeroed background level at a predetermined distance from the $1/e^2$ diameter. Some software allows the user to override this distance.

4. Acknowledgements.

Parts of this Application Note draw on Reference 2, and we have used the same notation wherever possible.

5. References

1. ISO 11146. "Optics and optical instruments. Lasers and laser related equipment. Test methods for Beam widths, divergence angle and beam propagation factor." Published by the International Organization for Standardization. Available from your national standards organization, ANSI in the US.

2. T. F. Johnston Jr., "Beam propagation (M^2) measurement made as easy as it gets: the four-cuts method", Applied Optics, Vol. 37, No. 21, 20 July 1998, pp. 4840-4850.

APPENDIX C: SUPPORT, RETURNS, DISTRIBUTORS, REPS

DataRay maintains a network of knowledgeable Distributors and Representatives, and also offer direct product support. Contact details vary with time, and therefore have not been included here. Visit the website for a complete listing.

Service, Returns/RMAs, Repairs, Equipment Problems, Recalibration

If you did not receive the product directly from DataRay, contact the vendor directly. If you did receive the product directly from DataRay, see the current procedure for returning product for repair posted at the website, under **Returns/Repairs** in the **Sales & Support** menu. The simple steps below are designed to minimize the number of calls that you need to make, minimize time to handle the issue, minimize your costs and our costs, and get you back to a working system as soon as possible. Current support contacts are at the website.

Remember:

- There is a three-year product warranty on all standard DataRay manufactured product (excluding customer damage). Third party manufactured items normally carry a one-year warranty. Outside the warranty period, there is a reasonable minimum repair charge that covers many issues other than customer damage.
- Repair turnaround time target is 5-15 working days.

1) Clearly identify the problem and write it down. Have the name, contact number and email address of the person with direct experience of the problem at hand when you call. Save relevant ***.dat**, ***.bmf**, ***.bmp**, ***.bmr**, ***.wcf**, ***.bsf** etc. files, including reference files, so that you can show us the problem. [If a third party is going to call us to arrange the return, all this is even more essential.]

> **Tip 1**: Do check that everything is correctly plugged in. Never unplug a head (except WinCamD heads) while the software is on. Where possible, check hardware and cables by substitution. Use static safe procedures when working with PC cards or disconnected heads.
>
> **Tip 2**: If '*The software is not working like it used to*', remember that you can flush the software to its default configuration by going to **File**, **Load Defaults**. You may also download software upgrades for free from **Software Upgrades** at the website.

2) If you have a production line down due to equipment failure, or some other time crisis, call Technical Support.

3) If you are sure that the equipment must be returned, e.g. it is physically damaged or it was an evaluation item, go to step 5).

4) If it is not working, but you are not sure why, contact Technical Support. We can frequently solve problems over the phone, or identify the problem well enough to

minimize turnaround time on returned equipment and/or the number of items that need to be returned.

5) Generate the paperwork. [Not providing the paperwork inevitably leads to delays]:

a) Print it out the RMA form if found at the website, fill it out, keep a copy for your records and include a good copy with the shipment.

   For products purchased from DataRay, generate your own RMA (Returned Materials Authorization) reference number per the RMA form.

b) Mark the number on the RMA form, the outside of the shipping box and on the packing list attached to the outside of the shipping box:

6) Pack it properly.

- Where possible use the original packaging.
- Always ensure that all boards and hardware with electrical connections is first wrapped in static dissipative foam [pink or mauve] or bag [metallic silver/gray].
- If an improperly wrapped item is found to be zapped by static, then we must charge you for the replacement.
- Include the cables.

7) Return the equipment to the address on the RMA form.

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